Docket No: P-5235-US14

METABOLITES OF SELECTIVE ANDROGEN RECEPTOR MODULATORS AND METHODS OF USE THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation-in-Part of US Serial No. 10/270,233, filed October 15, 2002, which is a Continuation-in-Part Application of US Serial No. 09/935,044, filed August 23, 2001 and of US Serial No. 09/935,045, filed August 23, 2001, which are Continuation-in-Part Applications of US Serial No. 09/644,970 filed August 24, 2000; and claims priority of US Serial No. 60/300,083, filed June 25, 2001, which are hereby incorporated by reference.

GOVERNMENT INTEREST STATEMENT

[0002] This invention was made in whole or in part with government support under grant number R01 DK59800 awarded by the National Institute of Health. The government may have certain rights in the invention.

FIELD OF INVENTION

[0003] The present invention relates to metabolites of a novel class of androgen receptor targeting agents (ARTA), which are selective androgen receptor modulators (SARM). The SARM compounds and their metabolites are useful for a) male contraception; b) treatment of a variety of hormone-related conditions, for example conditions associated with Androgen Decline in Aging Male (ADAM), such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, anemia, obesity, sarcopenia, osteopenia, osteoporosis, benign prostate hyperplasia, alterations in mood and cognition and prostate cancer; c) treatment of conditions associated with Androgen Decline in Female (ADIF), such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer; d) treatment and/or prevention of acute and/or chronic muscular wasting conditions; e) preventing and/or treating dry eye conditions; f)

oral androgen replacement therapy; g) decreasing the incidence of, halting or causing a regression of prostate cancer; and/or h) inducing apoptosis in a cancer cell.

BACKGROUND OF THE INVENTION

[0004] The androgen receptor ("AR") is a ligand-activated transcriptional regulatory protein that mediates induction of male sexual development and function through its activity with endogenous androgens. Androgens are generally known as the male sex hormones. The androgenic hormones are steroids which are produced in the body by the testes and the cortex of the adrenal gland or can be synthesized in the laboratory. Androgenic steroids play an important role in many physiologic processes, including the development and maintenance of male sexual characteristics such as muscle and bone mass, prostate growth, spermatogenesis, and the male hair pattern (Matsumoto, Endocrinol. Met. Clin. N. Am. 23:857-75 (1994)). The endogenous steroidal androgens include testosterone and dihydrotestosterone ("DHT"). Testosterone is the principal steroid secreted by the testes and is the primary circulating androgen found in the plasma of males. Testosterone is converted to DHT by the enzyme 5 alpha-reductase in many peripheral tissues. DHT is thus thought to serve as the intracellular mediator for most androgen actions (Zhou, et al., Molec. Endocrinol. 9:208-18 (1995)). Other steroidal androgens include esters of testosterone, such as the cypionate, propionate, phenylpropionate, cyclopentylpropionate, isocarporate, enanthate, and decanoate esters, and other synthetic androgens such as 7-Methyl-Nortestosterone ("MENT') and its acetate ester (Sundaram et al., "7 Alpha-Methyl-Nortestosterone(MENT): The Optimal Androgen For Male Contraception," Ann. Med., 25:199-205 (1993) ("Sundaram")). Because the AR is involved in male sexual development and function, the AR is a likely target for effecting male contraception or other forms of hormone replacement therapy.

[0005] Worldwide population growth and social awareness of family planning have stimulated a great deal of research in contraception. Contraception is a difficult subject under any circumstance. It is fraught with cultural and social stigma, religious implications, and, most certainly, significant health concerns. This situation is only exacerbated when the subject focuses on male contraception. Despite the availability of suitable contraceptive devices, historically, society has looked to women to be

responsible for contraceptive decisions and their consequences. Although concern over sexually transmitted diseases has made men more aware of the need to develop safe and responsible sexual habits, women still often bear the brunt of contraceptive choice. Women have a number of choices, from temporary mechanical devices such as sponges and diaphragms to temporary chemical devices such as spermicides. Women also have at their disposal more permanent options, such as physical devices including IUDs and cervical caps as well as more permanent chemical treatments such as birth control pills and subcutaneous implants. However, to date, the only options available for men include the use of condoms and vasectomy. Condom use, however is not favored by many men because of the reduced sexual sensitivity, the interruption in sexual spontaneity, and the significant possibility of pregnancy caused by breakage or misuse. Vasectomies are also not favored. If more convenient methods of birth control were available to men, particularly long-term methods which require no preparative activity immediately prior to a sexual act, such methods could significantly increase the likelihood that men would take more responsibility for contraception.

[0006] Administration of the male sex steroids (e.g., testosterone and its derivatives) has shown particular promise in this regard due to the combined gonadotropin-suppressing and androgen-substituting properties of these compounds (Steinberger et al., "Effect of Chronic Administration of Testosterone Enanthate on Sperm Production and Plasma Testosterone, Follicle Stimulating Hormone, and Luteinizing Hormone Levels: A Preliminary Evaluation of a Possible Male Contraceptive, Fertility and Sterility 28:1320-28 (1977)). Chronic administration of high doses of testosterone completely abolishes sperm production (azoospermia) or reduces it to a very low level (oligospermia). The degree of spermatogenic suppression necessary to produce infertility is not precisely known. However, a recent report by the World Health Organization showed that weekly intramuscular injections of testosterone enanthate result in azoospermia or severe oligospermia (i.e., less than 3 million sperm per ml) and infertility in 98% of men receiving therapy (World Health Organization Task Force on Methods And Regulation of Male Fertility, "Contraceptive Efficacy of Testosterone-Induced Azoospermia and Oligospermia in Normal Men," Fertility and Sterility 65:821-29 (1996)).

[0007] A variety of testosterone esters have been developed which are more slowly absorbed after intramuscular injection and thus result in greater androgenic effect. Testosterone enanthate is the most widely used of these esters. While testosterone enanthate has been valuable in terms of establishing the feasibility of hormonal agents for male contraception, it has several drawbacks, including the need for weekly injections and the presence of supraphysiologic peak levels of testosterone immediately following intramuscular injection (Wu, "Effects of Testosterone Enanthate in Normal Men: Experience From a Multicenter Contraceptive Efficacy Study," Fertility and Sterility 65:626-36 (1996)).

[0008] Steroidal ligands which bind the AR and act as androgens (e.g. testosterone enanthate) or as antiandrogens (e.g. cyproterone acetate) have been known for many years and are used clinically (Wu 1988). Although nonsteroidal antiandrogens are in clinical use for hormone-dependent prostate cancer, nonsteroidal androgens have not been reported. For this reason, research on male contraceptives has focused solely on steroidal compounds.

[0009] Prostate cancer is one of the most frequently occurring cancers among men in the United States, with hundreds of thousands of new cases diagnosed each year. Unfortunately, over sixty percent of newly diagnosed cases of prostate cancer are found to be pathologically advanced, with no cure and a dismal prognosis. One approach to this problem is to find prostate cancer earlier through screening programs and thereby reduce the number of advanced prostate cancer patients. Another strategy, however, is to develop drugs to prevent prostate cancer. One third of all men over 50 years of age have a latent form of prostate cancer that may be activated into the life-threatening clinical prostate cancer form. The frequency of latent prostatic tumors has been shown to increase substantially with each decade of life from the 50s (5.3-14%) to the 90s (40-80%). The number of people with latent prostate cancer is the same across all cultures, ethnic groups, and races, yet the frequency of clinically aggressive cancer is markedly different. This suggests that environmental factors may play a role in activating latent prostate cancer. Thus, the development of treatment and preventative strategies against

prostate cancer may have the greatest overall impact both medically and economically against prostate cancer.

[00010] Osteoporosis is a systemic skeletal diseaseor Characterized by low bone mass and deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture. In the U.S., the condition affects more than 25 million people and causes more than 1.3 million fractures each year, including 500,000 spine, 250,000 hip and 240,000 wrist fractures annually. Hip fractures are the most serious consequence of osteoporosis, with 5-20% of patients dying within one year, and over 50% of survivors being incapacitated. The elderly are at greatest risk of osteoporosis, and the problem is therefore predicted to increase significantly with the aging of the population. Worldwide fracture incidence is forecasted to increase three-fold over the next 60 years, and one study estimated that there will be 4.5 million hip fractures worldwide in 2050.

[00011] Women are at greater risk of osteoporosis than men. Women experience a sharp acceleration of bone loss during the five years following menopause. Other factors that increase the risk include smoking, alcohol abuse, a sedentary lifestyle and low calcium intake. However, osteoporosis also occurs frequently in males. It is well established that the bone mineral density of males decrease with age. Decreased amounts of bone mineral content and density correlates with decreased bone strength, and predisposes to fracture. The molecular mechanisms underlying the pleiotropic effects of sex-hormones in non-reproductive tissues are only beginning to be understood, but it is clear that physiologic concentrations of androgens and estrogens play an important role in maintaining bone homeostasis throughout the life-cycle. Consequently, when androgen or estrogen deprivation occurs there is a resultant increase in the rate of bone remodeling that tilts the balance of resorption and formation to the favor of resorption that contributes to the overall loss of bone mass. In males, the natural decline in sex-hormones at maturity (direct decline in androgens as well as lower levels of estrogens derived from peripheral aromatization of androgens) is associated with the frailty of bones. This effect is also observed in males who have been castrated.

[00012] Androgen decline in the aging male (ADAM) refers to a progressive decrease in androgen production, common in males after middle age. The syndrome is characterized

by alterations in the physical and intellectual domains that correlate with and can be corrected by manipulation of the androgen milieu. ADAM is characterized biochemically by a decrease not only in serum androgen, but also in other hormones, such as growth hormone, melatonin and dehydroepiandrosterone. Clinical manifestations include fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, obesity, sarcopenia, osteopenia, benign prostate hyperplasia, and alterations in mood and cognition.

[00013] Androgen Deficiency in Female (ADIF) refers to a variety of hormone-related conditions including, common in females after middle agest. The syndrome is characterized by sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, anemia, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer.

[00014] Muscle wasting refers to the progressive loss of muscle mass and/or to the progressive weakening and degeneration of muscles, including the skeletal or voluntary muscles, which control movement, cardiac muscles, which control the heart (cardiomyopathics), and smooth muscles. Chronic muscle wasting is a chronic condition (i.e. persisting over a long period of time) characterized by progressive loss of muscle mass, weakening and degeneration of muscle. The loss of muscle mass that occurs during muscle wasting can be characterized by a muscle protein breakdown or degradation. Protein degradation occurs because of an unusually high rate of protein degradation, an unusually low rate of protein synthesis, or a combination of both. Protein degradation, whether caused by a high degree of protein degradation or a low degree of protein synthesis, leads to a decrease in muscle mass and to muscle wasting. Muscle wasting is associated with chronic, neurological, genetic or infectious pathologies, diseases, illnesses or conditions. These include Muscular Dystrophies such as Duchenne Muscular Dystrophy and Myotonic Dystrophy; Muscle Atrophies such as Post-Polio Muscle Atrophy (PPMA); Cachexias such as Cardiac Cachexia, AIDS Cachexia and Cancer Cachexia, malnutrition, Leprosy, Diabetes, Renal Diseaseor CHronic Obstructive Pulmonary Disease (COPD), Cancer, end stage Renal failure, Emphysema, Osteomalacia, HIV Infection, AIDS, and Cardiomyopathy, In addition,

other circumstances and conditions are linked to and can cause muscle wasting. These include chronic lower back pain, advanced age, central nervous system (CNS) injury, peripheral nerve injury, spinal cord injuryor Chemical injury, central nervous system (CNS) damage, peripheral nerve damage, spinal cord damageor CHemical damage, burns, disuse deconditioning that occurs when a limb is immobilized, long term hospitalization due to illness or injury, and alcoholism. Muscle wasting, if left unabated, can have dire health consequences. For example, the changes that occur during muscle wasting can lead to a weakened physical state that is detrimental to an individual's health, resulting in increased susceptibility to infection, poor performance status and susceptibility to injury.

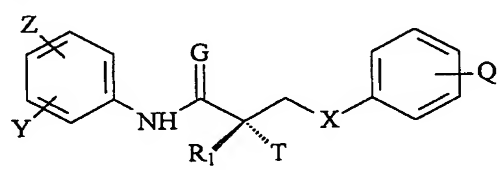
[00015]New innovative approaches are urgently needed at both the basic science and clinical levels to develop compounds which are useful for a) male contraception; b) treatment of a variety of hormone-related conditions, for example conditions associated with Androgen Decline in Aging Male (ADAM), such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, anemia, obesity, sarcopenia, osteopenia, osteoporosis, benign prostate hyperplasia, alterations in mood and cognition and prostate cancer; c) treatment of conditions associated with ADIF, such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer; d) treatment and/or prevention of acute and/or chronic muscular wasting conditions; e) preventing and/or treating dry eye conditions; f) oral androgen replacement therapy; and/or g) decreasing the incidence of, halting or causing a regression of prostate cancer.

SUMMARY OF THE INVENTION

[00016]This invention provides metabolites of a class of androgen receptor targeting agents (ARTA). The agents define a new subclass of compounds, which are selective androgen receptor modulators (SARM). The SARM compounds and their metabolites, either alone or as a composition, are useful for **a)** male contraception; **b)** treatment of a variety of hormone-related conditions, for example conditions associated with Androgen

Decline in Aging Male (ADAM), such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, anemia, obesity, sarcopenia, osteopenia, osteoporosis, benign prostate hyperplasia, alterations in mood and cognition and prostate cancer; **c)** treatment of conditions associated with Androgen Decline in Female (ADIF), such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer;. **d)** treatment and/or prevention of acute and/or chronic muscular wasting conditions; **e)** preventing and/or treating dry eye conditions; **f)** oral androgen replacement therapy; **g)** decreasing the incidence of, halting or causing a regression of prostate cancer; and/or **h)** inducing apoptosis in a cancer cell.

[00017] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula I:



I

wherein G is O or S;

X is O;

T is OH, OR, $-NHCOCH_3$, or NHCOR;

Z is NO_2, CN, COOH, COR, NHCOR or CONHR;

Y is CF_3, F, I, Br, Cl, CN, CR_3 or SnR_3;

Q is acetamido or trifluoroacetamido;

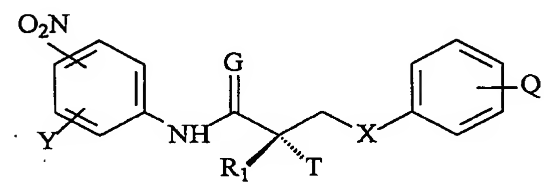
R is alkyl, haloalkyl, dihaloalkyl, trihaloalkyl, CH_2F, CHF_2, CF_3, CF_2CF_3, aryl, phenyl, F, Cl, Br, I, alkenyl or OH; and

R_1 is CH_3, CH_2F, CHF_2, CF_3, CH_2CH_3, or CF_2CF_3.

[00018] In one embodiment, G in compound I is O. In another embodiment, T in compound I is OH. In another embodiment, R_1 in compound I is CH_3. In another embodiment, Z in compound I is NO_2. In another embodiment, Z in compound I is CN.

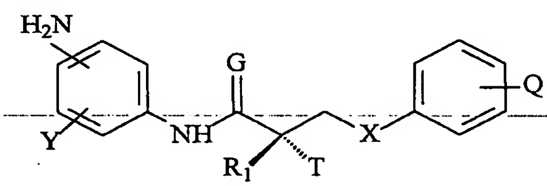
In another embodiment, Y in compound I is CF_3. In another embodiment, Q in compound I is $NHCOCH_3$. In another embodiment, Q in compound I is in the para position. In another embodiment, Z in compound I is in the para position. In another embodiment, Y in compound I is in the meta position. In another embodiment, G in compound I is O, T is OH, R_1 is CH_3, Z is NO_2, Y is CF_3, and Q is $NHCOCH_3$. In another embodiment, G in compound I is O, T is OH, Z is CN, Y is CF_3, and Q is $NHCOCH_3$.

[00019] In one embodiment, the SARM compound of formula I is represented by the structure of formula VII:

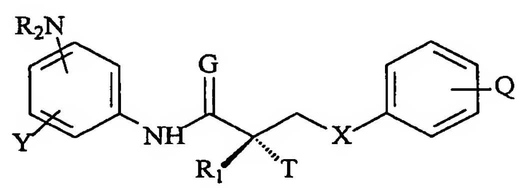


VII

[00020] In one embodiment, the metabolite of the SARM compound of formula VII is represented by the structure:

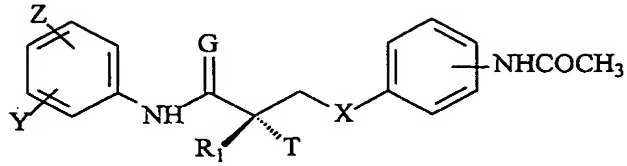


[00021] In another embodiment, the metabolite of the SARM compound of formula VII is represented by the structure:



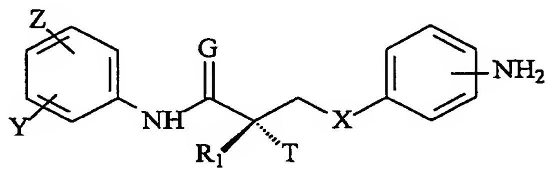
wherein NR_2 is NO, NHOH, $NHOSO_3$, or NHO-glucoronide.

[00022] In one embodiment, the SARM compound of formula I is represented by the structure of formula VIII:

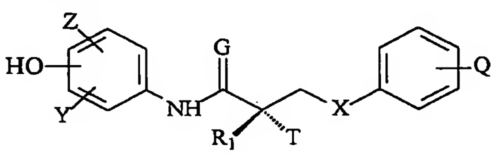


VIII

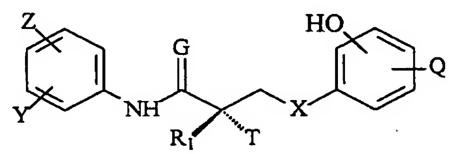
[00023] In one embodiment, the metabolite of the SARM compound of formula VIII is represented by the structure:



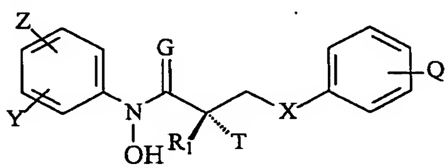
[00024] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula I. In accordance with this embodiment, the metabolite can be represented by the structure:



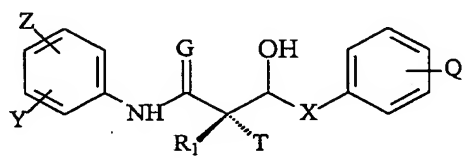
or



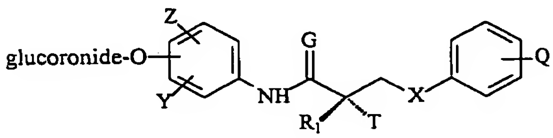
[00025] In another embodiment, the hydroxylated metabolite is represented by the structure:



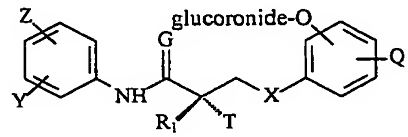
or



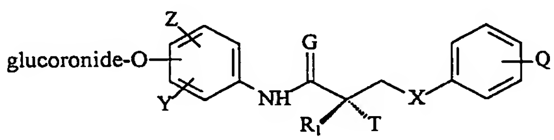
[00026] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the SARM compound of formula I. In accordance with this embodiment, the metabolite can be represented by the structure:



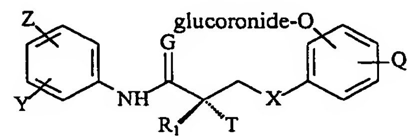
or



[00027] In another embodiment, the glucoronide metabolite is represented by the structure:

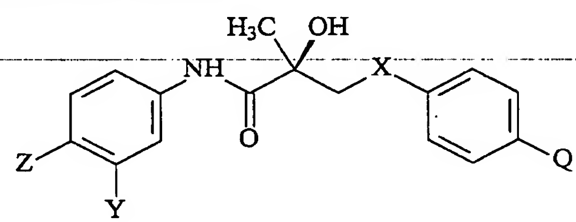


or



[00028] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula I.

[00029] In another embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula II:



II

wherein X is O;

Z is NO_2, CN, COOH, COR, NHCOR or CONHR;

Y is CF_3, F, I, Br, Cl, CN, CR_3 or SnR_3;

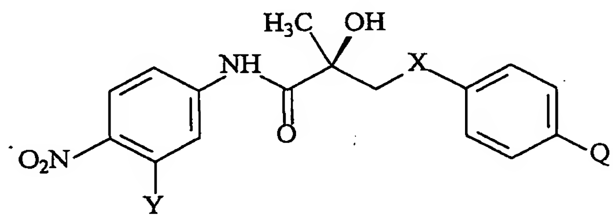
Q is acetamido or trifluoroacetamido;

R is alkyl, haloalkyl, dihaloalkyl, trihaloalkyl, CH_2F, CHF_2, CF_3, CF_2CF_3, aryl, phenyl, F, Cl, Br, I, alkenyl or OH; and

R_1 is CH_3, CH_2F, CHF_2, CF_3, CH_2CH_3, or CF_2CF_3.

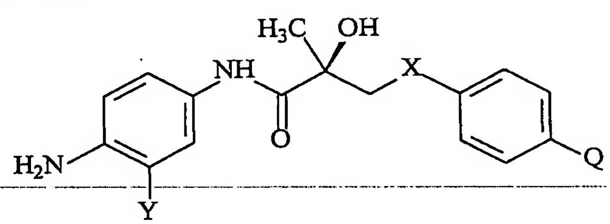
[00030] In one embodiment, Z in compound II is NO_2. In another embodiment, Z in compound II is CN. In another embodiment, Y in compound II is CF_3. In another embodiment, Q in compound II is $NHCOCH_3$. In another embodiment, Z in compound II is NO_2, Y is CF_3, and Q is $NHCOCH_3$. In another embodiment, Z in compound II is CN, Y is CF_3, and Q is $NHCOCH_3$.

[00031] In one embodiment, the SARM compound of formula II is represented by the structure of formula IX:

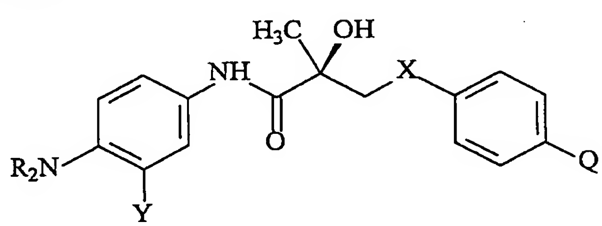


IX

[00032] In one embodiment, the metabolite of the SARM compound of formula IX is represented by the structure:

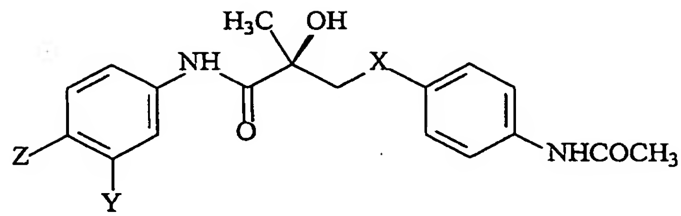


[00033] In another embodiment, the metabolite of the SARM compound of formula IX is represented by the structure:



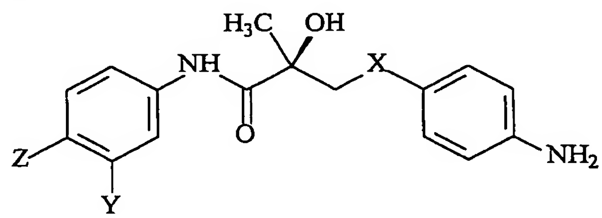
wherein NR_2 is NO, NHOH, $NHOSO_3$, or NHO-glucoronide.

[00034] In one embodiment, the SARM compound of formula II is represented by the structure of formula X:

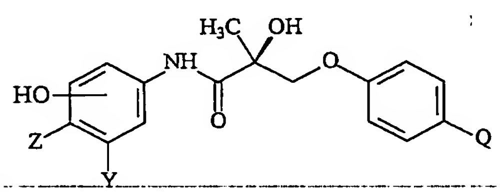


X

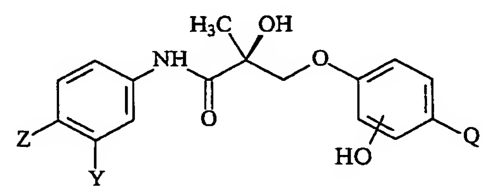
[00035] In one embodiment, the metabolite of the SARM compound of formula X is represented by the structure:



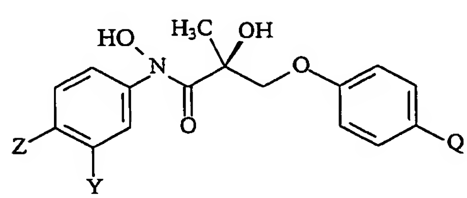
[00036] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula II. In accordance with this embodiment, the metabolite can be represented by the structure:



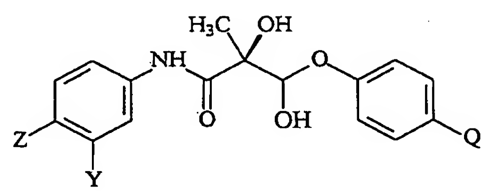
or



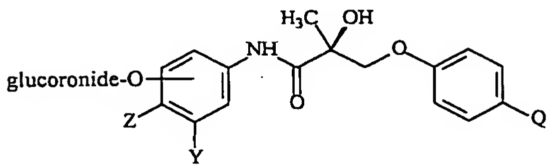
[00037] In another embodiment, the hydroxylated metabolite is represented by the structure:



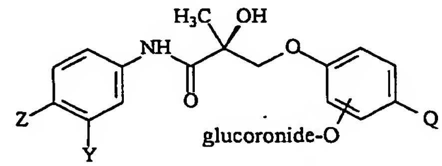
or



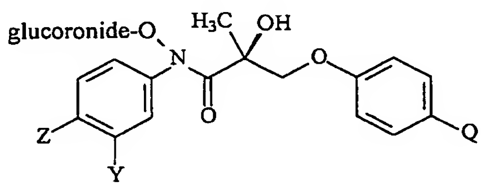
[00038] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the SARM compound of formula II. In accordance with this embodiment, the metabolite can be represented by the structure:



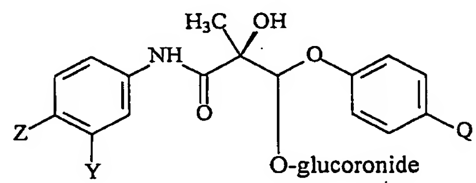
or



[00039] In another embodiment, the glucoronide metabolite is represented by the structure:

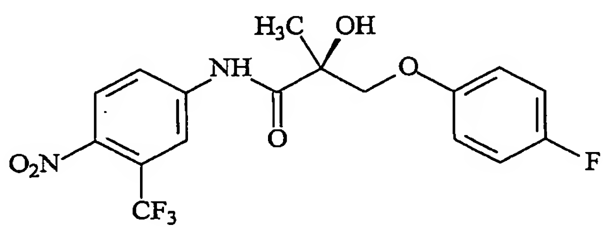


or



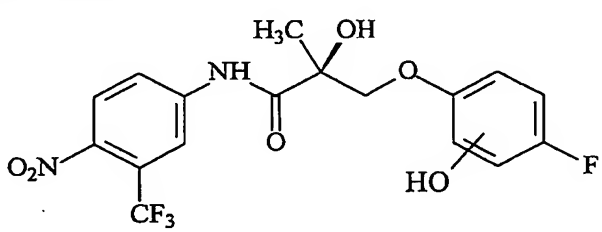
[00040] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula II.

[00041] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula III:

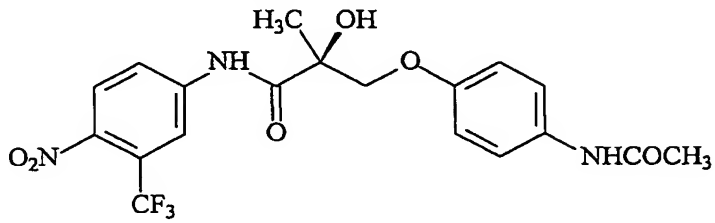


III

[00042] In one embodiment, the metabolite of the SARM compound of formula III is represented by the structure:

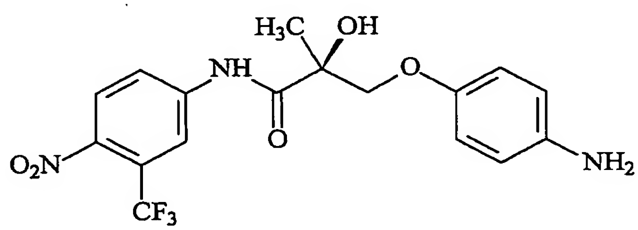


[00043] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula IV:

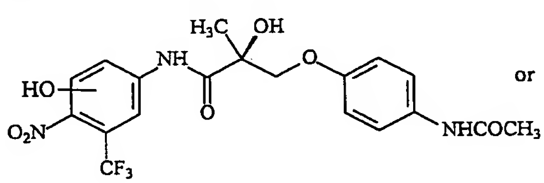


IV

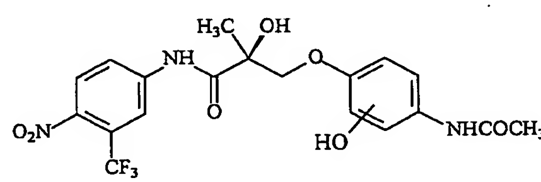
[00044] In one embodiment, the metabolite of the SARM compound of formula IV is represented by the structure:



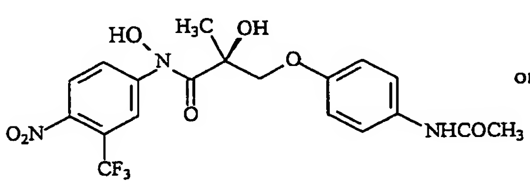
[00045] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula IV. In accordance with this embodiment, the metabolite can be represented by the structure:



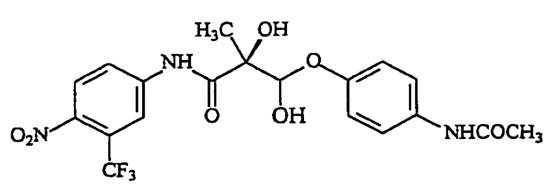
or



[00046] In another embodiment, the hydroxylated metabolite is represented by the structure:

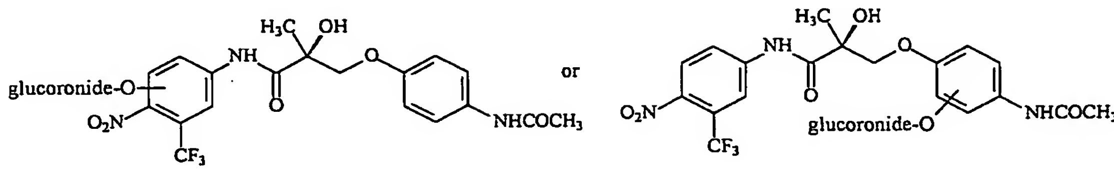


or

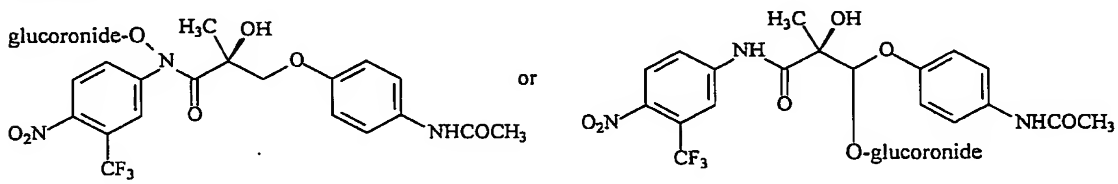


[00047] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the

SARM compound of formula IV. In accordance with this embodiment, the metabolite can be represented by the structure:



[00048] In another embodiment, the glucoronide metabolite is represented by the structure:



[00049] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula IV.

[00050] In one embodiment, the SARM metabolite is an androgen receptor agonist. In another embodiment, the SARM metabolite is an androgen receptor antagonist.

[00051] In one embodiment, the present invention provides a composition comprising the selective androgen receptor modulator metabolite of the present invention; and a suitable carrier or diluent.

[00052] In another embodiment, the present invention provides a pharmaceutical composition comprising the selective androgen receptor modulator metabolite of the present invention; and a suitable carrier or diluent.

[00053] In another embodiment, the present invention provides a method of binding a selective androgen receptor modulator compound to an androgen receptor, comprising the step of contacting the androgen receptor with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to bind the selective androgen receptor modulator compound to the androgen receptor.

[00054] In another embodiment, the present invention provides a method of suppressing spermatogenesis in a subject comprising contacting an androgen receptor of the subject with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to suppress sperm production.

[00055] In another embodiment, the present invention provides a method of contraception in a male subject, comprising the step of administering to the subject the selective androgen receptor modulator metabolite of the present invention, thereby effecting contraception in the subject.

[00056] In another embodiment, the present invention provides a method of hormone therapy comprising the step of contacting an androgen receptor of a subject with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to effect a change in an androgen-dependent condition.

[00057] In another embodiment, the present invention provides a method of hormone replacement therapy comprising the step of contacting an androgen receptor of a subject with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to effect a change in an androgen-dependent condition.

[00058] In another embodiment, the present invention provides a method of treating a subject having a hormone related condition, comprising the step of administering to the subject the selective androgen receptor modulator metabolite of the present invention, in an amount effective to effect a change in an androgen-dependent condition.

[00059] In another embodiment, the present invention provides a method of treating a subject suffering from prostate cancer, comprising the step of administering to said subject the selective androgen receptor modulator metabolite of the present invention, in an amount effective to treat prostate cancer in the subject.

[00060] In another embodiment, the present invention provides a method of preventing prostate cancer in a subject, comprising the step of administering to the subject the

selective androgen receptor modulator metabolite of the present invention, in an amount effective to prevent prostate cancer in the subject.

[00061] In another embodiment, the present invention provides a method of delaying the progression of prostate cancer in a subject suffering from prostate cancer, comprising the step of administering to said subject the selective androgen receptor modulator metabolite of the present invention, in an amount effective to delay the progression of prostate cancer in the subject.

[00062] In another embodiment, the present invention provides a method of preventing the recurrence of prostate cancer in a subject suffering from prostate cancer, comprising the step of administering to said subject the selective androgen receptor modulator metabolite of the present invention, in an amount effective to prevent the recurrence of prostate cancer in the subject.

[00063] In another embodiment, the present invention provides a method of treating the recurrence of prostate cancer in a subject suffering from prostate cancer, comprising the step of administering to said subject the selective androgen receptor modulator metabolite of the present invention, in an amount effective to treat the recurrence of prostate cancer in the subject.

[00064] In another embodiment, the present invention provides a method of treating a dry eye condition in a subject suffering from dry eyes, comprising the step of contacting an androgen receptor of a subject with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to treat dry eyes in the subject.

[00065] In another embodiment, the present invention provides a method of preventing a dry eye condition in a subject, comprising the step of contacting an androgen receptor of a subject with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to prevent dry eyes in the subject.

[00066] In another embodiment, the present invention provides a a method of inducing apoptosis in a cancer cell, comprising the step of contacting the cell with with the selective androgen receptor modulator metabolite of the present invention, in an amount effective to induce apoptosis in the cancer cell.

[00067] The novel selective androgen receptor modulator metabolites of the present invention, either alone or as a pharmaceutical composition, are useful for a) male contraception; b) treatment of a variety of hormone-related conditions, for example conditions associated with ADAM, such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, obesity, sarcopenia, osteopenia, benign prostate hyperplasia, and alterations in mood and cognition; c) treatment of conditions associated with ADIF, such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer; d) treatment and/or prevention of acute and/or chronic muscular wasting conditions; e) preventing and/or treating dry eye conditions; f) oral androgen replacement therapy; g) decreasing the incidence of, halting or causing a regression of prostate cancer; and/or h) inducing apoptosis in a cancer cell.

[00068] The selective androgen receptor modulator metabolites of the present invention offer a significant advance over steroidal androgen treatment. Several of the selective androgen receptor modulator compounds of the present invention have unexpected androgenic and anabolic activity of a nonsteroidal ligand for the androgen receptor. Other selective androgen receptor modulator compounds of the present invention have unexpected antiandrogenic activity of a nonsteroidal ligand for the androgen receptor. Thus, treatment with the selective androgen receptor modulator compounds of the present invention will not be accompanied by serious side effects, inconvenient modes of administration, or high costs and will still have the advantages of oral bioavailability, lack of cross-reactivity with other steroid receptors, and long biological half-lives.

BRIEF DESCRIPTION OF THE FIGURES

[00069] The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended figures which depict:

Figure 1: Androgenic and Anabolic activity of Compound IV in rats. Rats were left untreated (intact control), castrated (castrated control), treated with testosterone propionate (TP), or treated with Compound IV, and the body weight gain as well as the weight of androgen-responsive tissues (prostate, semimal vesicles and levator ani muscle) was determined.

Figure 2: Androgenic and Anabolic activity of Compound IV in rats. Rats were left untreated (intact control), castrated (castrated control), treated with 0.1, 0.3, 0.5, 0.75 and 1.0 mg/day testosterone propionate (TP), or treated with 0.1, 0.3, 0.5, 0.75 and 1.0 mg/day Compound IV, and the weight of androgen-responsive tissues (prostate, semimal vesicles and levator ani muscle) was determined.

Figure 3: Androgenic and Anabolic activity of Compound III in rats. Rats were left untreated (intact control), castrated (castrated control), treated with 0.1, 0.3, 0.5, 0.75 and 1.0 mg/day testosterone propionate (TP), or treated with 0.1, 0.3, 0.5, 0.75 and 1.0 mg/day Compound III, and the weight of androgen-responsive tissues (prostate, semimal vesicles and levator ani muscle) was determined.

Figure 4: Average plasma concentration-time profiles of Compound IV in beagle dogs after IV administration at 3 and 10 mg/kg.

Figure 5: Average plasma concentration-time profiles of Compound IV in beagle dogs after PO administration as solution at 10 mg/kg.

Figure 6: Average plasma concentration-time profiles of Compound IV in beagle dogs after IV administration as capsules at mg/kg.

Figure 7: Effects of Compound III and Compound IV on LH Levels.

Figure 8: Effects of Compound III and Compound IV on FSH Levels.

Figure 9: Synthesis scheme of Compound IV.

Figure 10: MS2 Spectra of Compound IV and its Amine Metabolite. Fig 10A: Fragmentation pattern of Compound IV. Fig 10b: Fragmentation pattern of Amine metabolite.

Figure 11: Radiographs of 24-hour Rat Urine and Feces samples after administration of Compound IV. Fig 11 A: Urine. Fig 11B: Feces.

Figure 12: Metabolic profile of Compound IV in rats and dogs.

Figure 13: *In vitro* metabolism of Compound IV by human recombinant CYP Supersomes® (n=2). Compound IV (2 μM) was incubated with human recombinant CYP Supersomes® (40 pmole) at 37°C for 2 hours. The disappearance of Compound IV was measured.

Figure 14: *In vitro* metabolism of Compound III by human recombinant CYP Supersomes® (n=2). Compound III (2 μM) was incubated with human recombinant CYP Supersomes® (40 pmole) at 37°C for 2 hours. The disappearance of Compound III was measured. After incubation, 20% of Compound III was metabolized by human CYP3A4.

Figure 15: *In vitro* metabolism of Compound IV in Human Liver Microsomes (HLM).

Figure 16: *In vitro* metabolism of Compound III in Human Liver Microsomes (HLM).

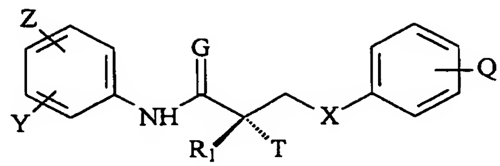
Figure 17: *In vitro* metabolism of Compound IV to M1 by CYPs. The appearance of M1 was measured in triplicate.

Figure 18. *In vitro* metabolism of Compound IV to M1 by HLM (0.2 mg/ml). The appearance of M1 was measured in triplicate.

DETAILED DESCRIPTION OF THE INVENTION

[00070] In one embodiment, this invention provides metabolites of a class of androgen receptor targeting agents (ARTA). The agents define a new subclass of compounds, which are selective androgen receptor modulators (SARM). Several of the SARM compounds have been found to have an unexpected androgenic and anabolic activity of a nonsteroidal ligand for the androgen receptor. The SARM compounds, either alone or as a composition, are useful for **a)** male contraception; **b)** treatment of a variety of hormone-related conditions, for example conditions associated with Androgen Decline in Aging Male (ADAM), such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, anemia, obesity, sarcopenia, osteopenia, osteoporosis, benign prostate hyperplasia, alterations in mood and cognition and prostate cancer; **c)** treatment of conditions associated with Androgen Decline in Female (ADIF), such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer; **d)** treatment and/or prevention of acute and/or chronic muscular wasting conditions; **e)** preventing and/or treating dry eye conditions; **f)** oral androgen replacement therapy; **g)** decreasing the incidence of, halting or causing a regression of prostate cancer; and/or **h)** inducing apoptosis in a cancer cell.

[00071] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula I:



I

wherein G is O or S;

X is O;

T is OH, OR, -$NHCOCH_3$, or NHCOR;

Z is NO_2, CN, COOH, COR, NHCOR or CONHR;

Y is CF_3, F, I, Br, Cl, CN, CR_3 or SnR_3;

Q is acetamido or trifluoroacetamido;

R is alkyl, haloalkyl, dihaloalkyl, trihaloalkyl, CH_2F, CHF_2, CF_3, CF_2CF_3, aryl, phenyl, F, Cl, Br, I, alkenyl or OH; and

R_1 is CH_3, CH_2F, CHF_2, CF_3, CH_2CH_3, or CF_2CF_3.

[00072] As contemplated herein, the present invention provides metabolites of the selective androgen receptor modulator of formula I. However, also contemplated within the scope of the present invention are analogs, isomers, metabolites, derivatives, pharmaceutically acceptable salts, pharmaceutical products, hydrates, N-oxides, impurities, polymorphs or crystals of the compound of formula I, or any combination thereof.

[00073] In one embodiment, this invention provides an analog of the compound of formula I. In another embodiment, this invention provides a derivative of the compound of formula I. In another embodiment, this invention provides an isomer of the compound of formula I. In another embodiment, this invention provides a metabolite of the compound of formula I. In another embodiment, this invention provides a pharmaceutically acceptable salt of the compound of formula I. In another embodiment, this invention provides a pharmaceutical product of the compound of formula I. In another embodiment, this invention provides a hydrate of the compound of formula I. In another embodiment, this invention provides an N-oxide of the compound of formula I. In another embodiment, this invention provides an impurity of the compound of formula I. In another embodiment, this invention provides a polymorph of the compound of

formula I. In another embodiment, this invention provides a crystal of the compound of formula I.

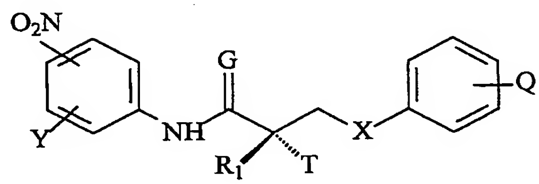
[00074] In another embodiment, this invention provides a combination of any of an analog, derivative, metabolite, isomer, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, impurity, metabolite, polymorph or crystal of the compound of formula I.

[00075] In one embodiment, G in compound I is O. In another embodiment, T in compound I is OH. In another embodiment, R_1 in compound I is CH_3. In another embodiment, Z in compound I is NO_2. In another embodiment, Z in compound I is CN. In another embodiment, Y in compound I is CF_3. In another embodiment, Q in compound I is $NHCOCH_3$. In another embodiment, Q in compound I is in the para position. In another embodiment, Z in compound I is in the para position. In another embodiment, Y in compound I is in the meta position. In another embodiment, G in compound I is O, T is OH, R_1 is CH_3, Z is NO_2, Y is CF_3, and Q is $NHCOCH_3$. In another embodiment, G in compound I is O, T is OH, R_1 is CH_3, Z is CN, Y is CF_3, and Q is $NHCOCH_3$.

[00076] The substituents Z and Y can be in any position of the ring carrying these substituents (hereinafter "A ring"). In one embodiment, the substituent Z is in the para position of the A ring. In another embodiment, the substituent Y is in the meta position of the A ring. In another embodiment, the substituent Z is in the para position of the A ring and substituent Y is in the meta position of the A ring.

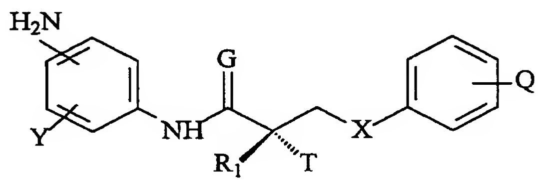
[00077] The substituent Q can be in any position of the ring carrying this substituent (hereinafter "B ring"). In one embodiment, the substituent Q is in the para position of the B ring. In another embodiment, the substituent Q is $NHCOCH_3$ and is in the para position of the B ring. In another embodiment, the substituent Q is F and is in the para position of the B ring.

[00078] In one embodiment, the SARM compound of formula I is represented by the structure of formula VII:

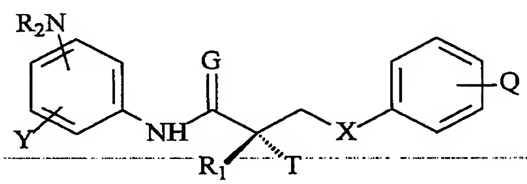


VII

[00079] In one embodiment, the metabolite of the SARM compound of formula VII is represented by the structure:

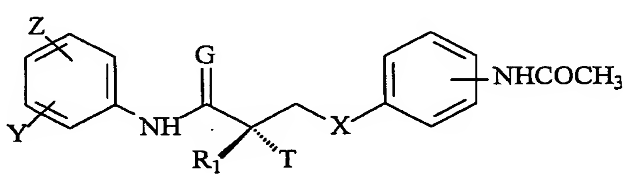


[00080] In another embodiment, the metabolite of the SARM compound of formula VII is represented by the structure:



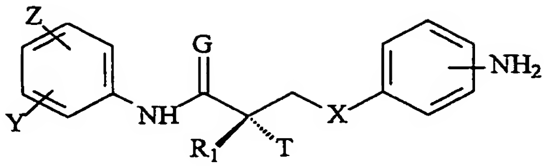
wherein NR_2 is NO, NHOH, $NHOSO_3$, or NHO-glucoronide.

[00081] In one embodiment, the SARM compound of formula I is represented by the structure of formula VIII:

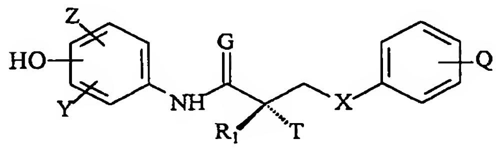


VIII

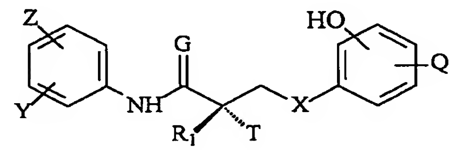
[00082] In one embodiment, the metabolite of the SARM compound of formula VIII is represented by the structure:



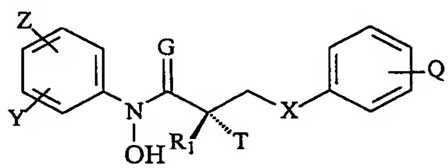
[00083] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula I. In accordance with this embodiment, the metabolite can be represented by the structure:



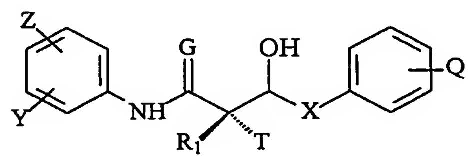
or



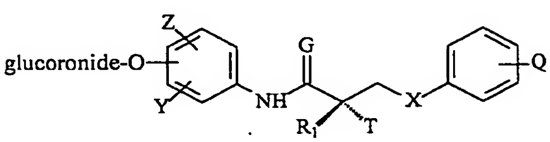
[00084] In another embodiment, the hydroxylated metabolite is represented by the structure:



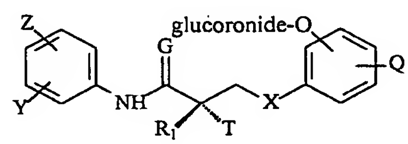
or



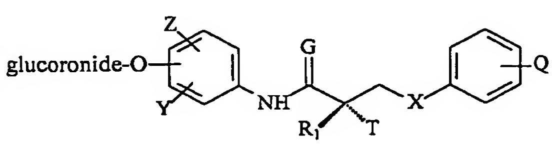
[00085] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the SARM compound of formula I. In accordance with this embodiment, the metabolite can be represented by the structure:



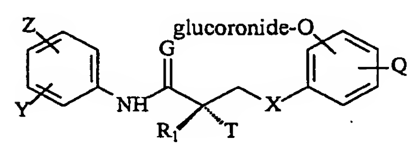
or



[00086] In another embodiment, the glucoronide metabolite is represented by the structure:

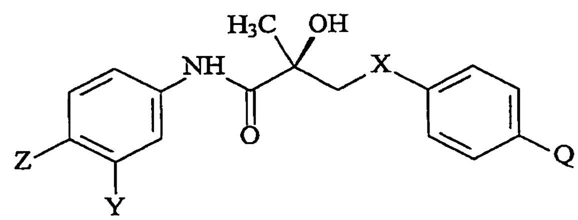


or



[00087] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula I.

[00088] In another embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula II:



II

wherein X is O;

Z is NO_2, CN, COOH, COR, NHCOR or CONHR;

Y is CF_3, F, I, Br, Cl, CN, CR_3 or SnR_3;

Q is acetamido or trifluoroacetamido;

R is alkyl, haloalkyl, dihaloalkyl, trihaloalkyl, CH_2F, CHF_2, CF_3, CF_2CF_3, aryl, phenyl, F, Cl, Br, I, alkenyl or OH; and

R_1 is CH_3, CH_2F, CHF_2, CF_3, CH_2CH_3, or CF_2CF_3.

[00089] As contemplated herein, the present invention provides metabolites of the selective androgen receptor modulator of formula II. However, also contemplated within the scope of the present invention are analogs, isomers, metabolites, derivatives, pharmaceutically acceptable salts, pharmaceutical products, hydrates, N-oxides, impurities, polymorphs or crystals of the compound of formula II, or any combination thereof.

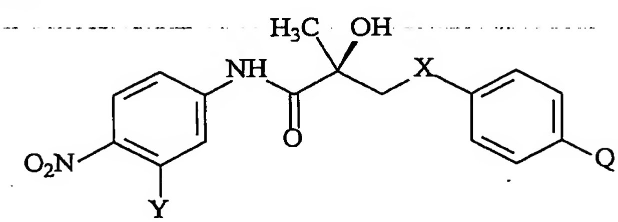
[00090] In one embodiment, this invention provides an analog of the compound of formula II. In another embodiment, this invention provides a derivative of the compound of formula II. In another embodiment, this invention provides an isomer of the compound of formula II. In another embodiment, this invention provides a metabolite of the compound of formula II. In another embodiment, this invention provides a pharmaceutically acceptable salt of the compound of formula II. In another embodiment,

this invention provides a pharmaceutical product of the compound of formula II. In another embodiment, this invention provides a hydrate of the compound of formula II. In another embodiment, this invention provides an N-oxide of the compound of formula II. In another embodiment, this invention provides an impurity of the compound of formula II. In another embodiment, this invention provides a polymorph of the compound of formula II. In another embodiment, this invention provides a crystal of the compound of formula II.

[00091] In another embodiment, this invention provides a combination of any of an analog, derivative, metabolite, isomer, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, impurity, metabolite, polymorph or crystal of the compound of formula II.

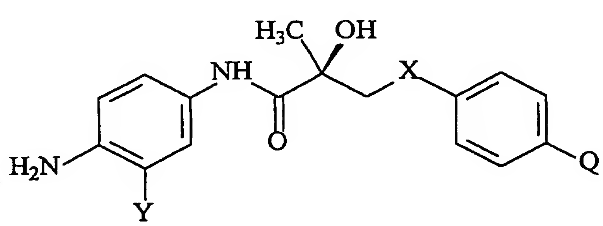
[00092] In one embodiment, Z in compound II is NO_2. In another embodiment, Z in compound II is CN. In another embodiment, Y in compound II is CF_3. In another embodiment, Q in compound II is $NHCOCH_3$.

[00093] In one embodiment, the SARM compound of formula II is represented by the structure of formula IX:

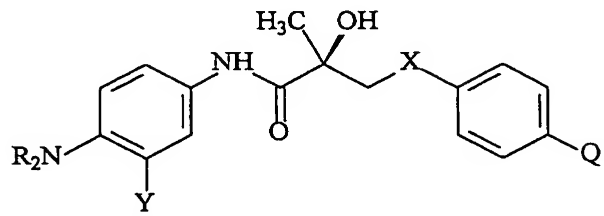


IX

[00094] In one embodiment, the metabolite of the SARM compound of formula IX is represented by the structure:

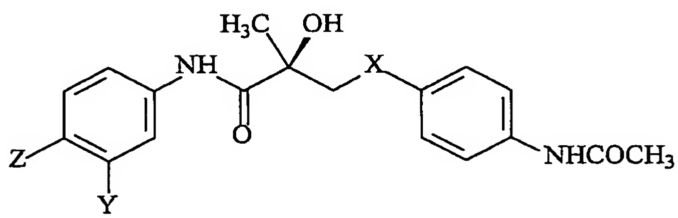


[00095] In another embodiment, the metabolite of the SARM compound of formula IX is represented by the structure:



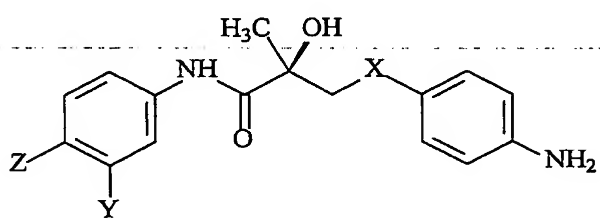
wherein NR_2 is NO, NHOH, $NHOSO_3$, or NHO-glucoronide.

[00096] In one embodiment, the SARM compound of formula II is represented by the structure of formula X:

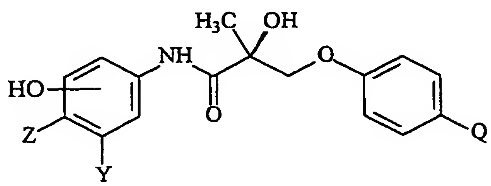


X

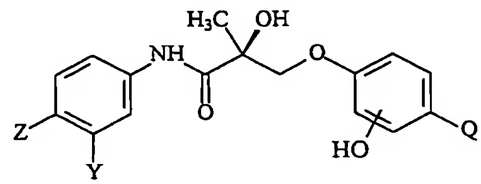
[00097] In one embodiment, the metabolite of the SARM compound of formula X is represented by the structure:



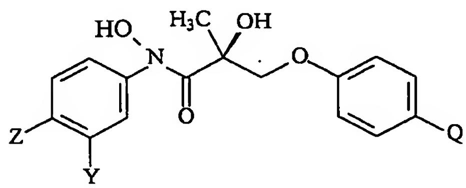
[00098] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula II. In accordance with this embodiment, the metabolite can be represented by the structure:



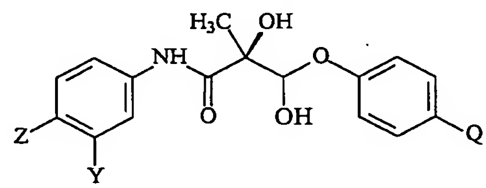
or



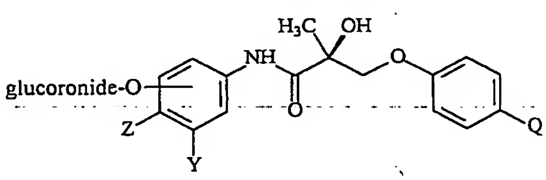
[00099] In another embodiment, the hydroxylated metabolite is represented by the structure:



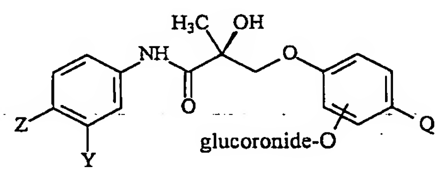
or



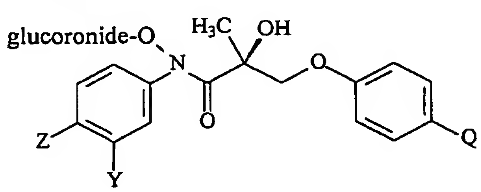
[000100] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the SARM compound of formula II. In accordance with this embodiment, the metabolite can be represented by the structure:



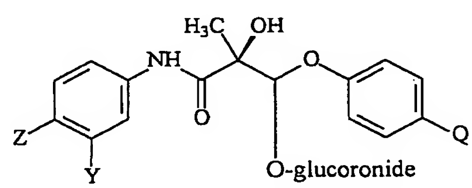
or



[000101] In another embodiment, the glucoronide metabolite is represented by the structure:

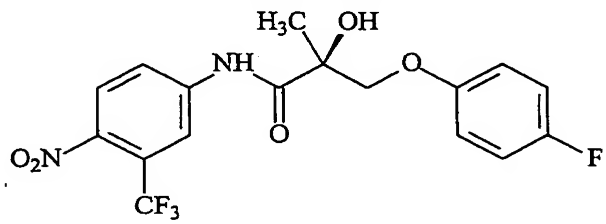


or



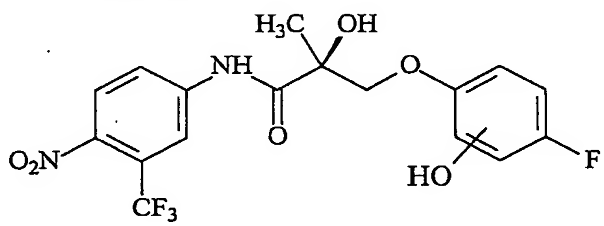
[000102] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula II.

[000103] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula III:

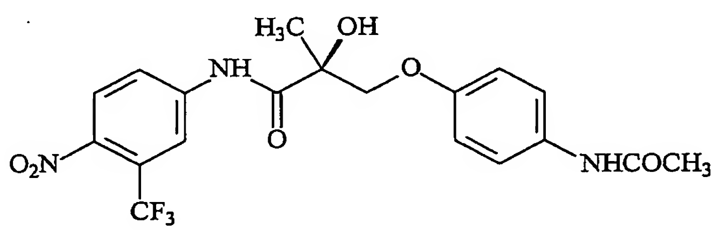


III

[000104] In one embodiment, the metabolite of the SARM compound of formula III is represented by the structure:

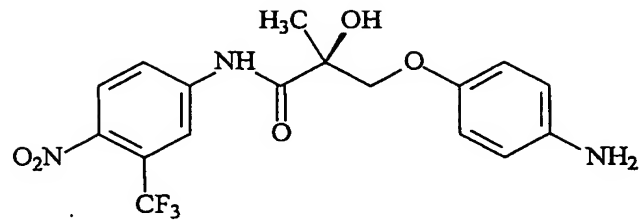


[000105] In one embodiment, the present invention provides a metabolite of a selective androgen receptor modulator (SARM) compound, wherein the SARM compound is represented by the structure of formula IV:

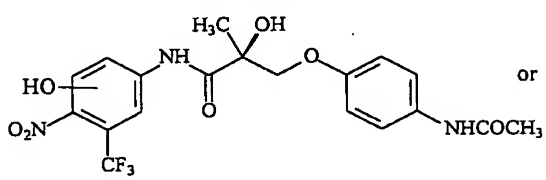


IV

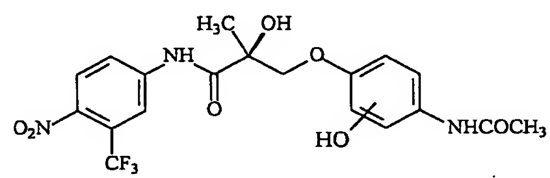
[000106] In one embodiment, the metabolite of the SARM compound of formula IV is represented by the structure:



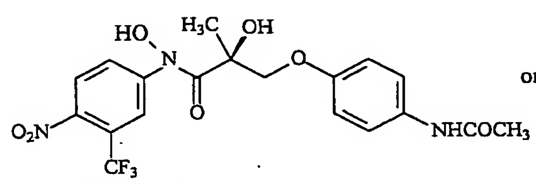
[000107] In one embodiment, the SARM metabolite is a hydroxylated derivative of the SARM compound of formula IV. In accordance with this embodiment, the metabolite can be represented by the structure:



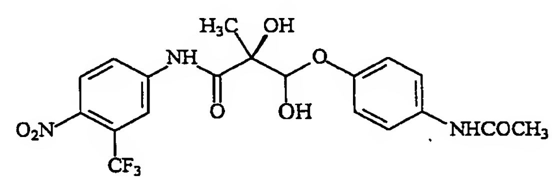
or



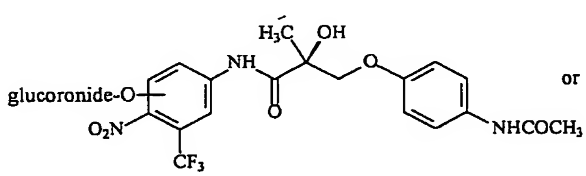
[000108] In another embodiment, the hydroxylated metabolite is represented by the structure:



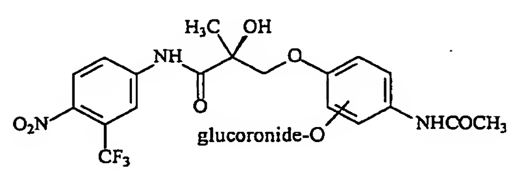
or



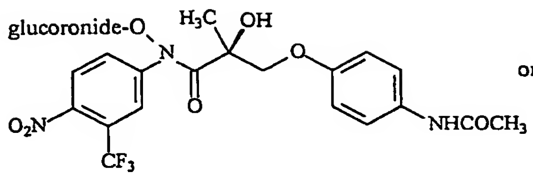
[000109] In one embodiment, the SARM metabolite is an O-glucoronide derivative of the SARM compound of formula IV. In accordance with this embodiment, the metabolite can be represented by the structure:



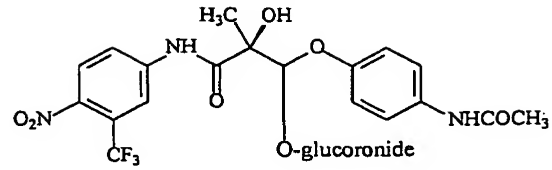
or



[000110] In another embodiment, the glucoronide metabolite is represented by the structure:



or



[000111] In another embodiment, the SARM metabolite is a methylated derivative of the SARM compound of formula IV.

[000112] In one embodiment, the SARM metabolite is an androgen receptor agonist. In another embodiment, the SARM metabolite is an androgen receptor antagonist.

DEFINITIONS

[000113] The substituent R is defined herein as an alkyl, haloalkyl, dihaloalkyl, trihaloalkyl, CH_2F, CHF_2, CF_3, CF_2CF_3; aryl, phenyl, F, Cl, Br, I, alkenyl, or hydroxyl (OH).

[000114] An "alkyl" group refers to a saturated aliphatic hydrocarbon, including straight-chain, branched-chain and cyclic alkyl groups. In one embodiment, the alkyl group has 1-12 carbons. In another embodiment, the alkyl group has 1-7 carbons. In another embodiment, the alkyl group has 1-6 carbons. In another embodiment, the alkyl group has 1-4 carbons. The alkyl group may be unsubstituted or substituted by one or more groups selected from halogen (e.g. F, Cl, Br, I), hydroxy, alkoxy carbonyl, amido, alkylamido, dialkylamido, nitro, amino, alkylamino, dialkylamino, carboxyl, thio and thioalkyl.

[000115] A "haloalkyl" group refers to an alkyl group as defined above, which is substituted by one or more halogen atoms, e.g. by F, Cl, Br or I. A "halogen" refers to elements of Group VII or the periodic table, e.g. F, Cl, Br or I.

[000116] An "aryl" group refers to an aromatic group having at least one carbocyclic aromatic group or heterocyclic aromatic group, which may be unsubstituted or substituted by one or more groups selected from halogen (e.g. F, Cl, Br, I), haloalkyl,

hydroxy, alkoxy carbonyl, amido, alkylamido, dialkylamido, nitro, amino, alkylamino, dialkylamino, carboxy or thio or thioalkyl. Nonlimiting examples of aryl rings are phenyl, naphthyl, pyranyl, pyrrolyl, pyrazinyl, pyrimidinyl, pyrazolyl, pyridinyl, furanyl, thiophenyl, thiazolyl, imidazolyl, isoxazolyl, and the like.

[000117] A "hydroxyl" group refers to an OH group. An "alkenyl" group refers to a group having at least one carbon to carbon double bond.

[000118] An "arylalkyl" group refers to an alkyl bound to an aryl, wherein alkyl and aryl are as defined above. An example of an aralkyl group is a benzyl group.

[000119] As contemplated herein, the present invention relates to the use of a metabolite of the selective androgen receptor modulator of the present invention. However, also contemplated within the scope of the present invention are analogs, isomers, metabolites, derivatives, pharmaceutically acceptable salts, pharmaceutical products, hydrates, N-oxides, impurities, polymorphs or crystals of the compound of the present invention or any combination thereof.

[000120] In one embodiment, the invention relates to the use of an analog of the SARM compound. In another embodiment, the invention relates to the use of a derivative of the SARM compound. In another embodiment, the invention relates to the use of an isomer of the SARM compound. In another embodiment, the invention relates to the use of a metabolite of the SARM compound. In another embodiment, the invention relates to the use of a pharmaceutically acceptable salt of the SARM compound. In another embodiment, the invention relates to the use of a pharmaceutical product of the SARM compound. In another embodiment, the invention relates to the use of a hydrate of the SARM compound. In another embodiment, the invention relates to the use of an N-oxide of the SARM compound. compound. In another embodiment, the invention relates to the use of a polymorph of the SARM compound. In another embodiment, the invention relates to the use of a crystal of the SARM compound.

[000121] In another embodiment, the invention relates to the use of any of a combination of an analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, or N-oxide, metabolite, polymorph or crystal of the SARM compounds of the present invention.

[000122] As defined herein, the term "metabolite" means a substance which can be converted in-vivo into a biologically active agent by such reactions as hydrolysis, esterification, desterification, activation, salt formation and the like.

[000123] As defined herein, the term "isomer" includes, but is not limited to, optical isomers and analogs, structural isomers and analogs, conformational isomers and analogs, and the like.

[000124] In one embodiment, this invention encompasses the use of various optical isomers of the SARM compounds. It will be appreciated by those skilled in the art that the SARM compounds of the present invention contain at least one chiral center. Accordingly, the SARM compounds used in the methods of the present invention may exist in, and be isolated in, optically-active or racemic forms. Some compounds may also exhibit polymorphism. It is to be understood that the present invention encompasses any racemic, optically-active, polymorphic, or stereroisomeric form, or mixtures thereof, which form possesses properties useful in the methods as described herein. In one embodiment, the SARM compounds are the pure (R)-isomers. In another embodiment, the SARM compounds are the pure (S)-isomers. In another embodiment, the SARM compounds are a mixture of the (R) and the (S) isomers. In another embodiment, the SARM compounds are a racemic mixture comprising an equal amount of the (R) and the (S) isomers. It is well known in the art how to prepare optically-active forms (for example, by resolution of the racemic form by recrystallization techniques, by synthesis from optically-active starting materials, by chiral synthesis, or by chromatographic separation using a chiral stationary phase).

[000125] The invention includes pharmaceutically acceptable salts of amino-substituted compounds with organic and inorganic acids, for example, citric acid and hydrochloric

acid. The invention also includes N-oxides of the amino substituents of the compounds described herein. Pharmaceutically acceptable salts can also be prepared from the phenolic compounds by treatment with inorganic bases, for example, sodium hydroxide. Also, esters of the phenolic compounds can be made with aliphatic and aromatic carboxylic acids, for example, acetic acid and benzoic acid esters.

[000126] This invention further includes derivatives of the SARM compounds. The term "derivatives" includes but is not limited to ether derivatives, acid derivatives, amide derivatives, ester derivatives and the like. In addition, this invention further includes hydrates of the SARM compounds. The term "hydrate" includes but is not limited to hemihydrate, monohydrate, dihydrate, trihydrate and the like.

[000127] This invention further includes metabolites of the SARM compounds. The term "metabolite" means any substance produced from another substance by metabolism or a metabolic process.

[000128] This invention further includes pharmaceutical products of the SARM compounds. The term "pharmaceutical product" means a composition suitable for pharmaceutical use (pharmaceutical composition), as defined herein.

[000129] This invention further includes crystals of the SARM compounds. Furthermore, this invention provides polymorphs of the SARM compounds. The term "crystal" means a substance in a crystalline state. The term "polymorph" refers to a particular crystalline state of a substance, having particular physical properties such as X-ray diffraction, IR spectra, melting point, and the like.

BIOLOGICAL ACTIVITY OF SELECTIVE ANDROGEN RECEPTOR MODULATOR COMPOUNDS

[000130] Selective androgen receptor modulator (SARM) compounds are a novel class of androgen receptor targeting agents ("ARTA"), that have previously been shown to be useful for a) male contraception; b) treatment of a variety of hormone-related

conditions, for example conditions associated with Androgen Decline in Aging Male (ADAM), such as fatigue, depression, decreased libido, sexual dysfunction, erectile dysfunction, hypogonadism, osteoporosis, hair loss, anemia, obesity, sarcopenia, osteopenia, osteoporosis, benign prostate hyperplasia, alterations in mood and cognition and prostate cancer; c) treatment of conditions associated with Androgen Decline in Female (ADIF), such as sexual dysfunction, decreased sexual libido, hypogonadism, sarcopenia, osteopenia, osteoporosis, alterations in cognition and mood, depression, anemia, hair loss, obesity, endometriosis, breast cancer, uterine cancer and ovarian cancer; d) treatment and/or prevention of acute and/or chronic muscular wasting conditions; e) preventing and/or treating dry eye conditions; f) oral androgen replacement therapy; g) decreasing the incidence of, halting or causing a regression of prostate cancer; and/or h) inducing apoptosis in a cancer cell.

[000131] As used herein, receptors for extracellular signaling molecules are collectively referred to as "cell signaling receptors". Many cell signaling receptors are transmembrane proteins on a cell surface; when they bind an extracellular signaling molecule (i.e., a ligand), they become activated so as to generate a cascade of intracellular signals that alter the behavior of the cell. In contrast, in some cases, the receptors are inside the cell and the signaling ligand has to enter the cell to activate them; these signaling molecules therefore must be sufficiently small and hydrophobic to diffuse across the plasma membrane of the cell.

[000132] Steroid hormones are one example of small hydrophobic molecules that diffuse directly across the plasma membrane of target cells and bind to intracellular cell signaling receptors. These receptors are structurally related and constitute the intracellular receptor superfamily (or steroid-hormone receptor superfamily). Steroid hormone receptors include progesterone receptors, estrogen receptors, androgen receptors, glueocorticoid receptors, and mineralocorticoid receptors. The present invention is particularly directed to androgen receptors.

[000133] In addition to ligand binding to the receptors, the receptors can be blocked to prevent ligand binding. When a substance binds to a receptor, the three-

dimensional structure of the substance fits into a space created by the three-dimensional structure of the receptor in a ball and socket configuration. The better the ball fits into the socket, the more tightly it is held. This phenomenon is called affinity. If the affinity of a substance is greater than the original hormone, it will compete with the hormone and bind the binding site more frequently. Once bound, signals may be sent through the receptor into the cell, causing the cell to respond in some fashion. This is called activation. On activation, the activated receptor then directly regulates the transcription of specific genes. But the substance and the receptor may have certain attributes, other than affinity, in order to activate the cell. Chemical bonds between atoms of the substance and the atoms of the receptors may form. In some cases, this leads to a change in the configuration of the receptor, which is enough to begin the activation process (called signal transduction).

[000134] In one embodiment, the present invention is directed to selective androgen receptor modulator compounds which are agonist compounds. A receptor agonist is a substance which binds receptors and activates them. Thus, in one embodiment, the SARM compounds of the present invention are useful in binding to and activating steroidal hormone receptors. In one embodiment, the agonist compound of the present invention is an agonist which binds the androgen receptor. In another embodiment, the compound has high affinity for the androgen receptor. In another embodiment, the agonist Compound B lso has anabolic activity. In another embodiment, the present invention provides selective androgen modulator compounds which have agonistic and anabolic activity of a nonsteroidal compound for the androgen receptor.

[000135] In another embodiment, the present invention is directed to selective androgen receptor modulator compounds which are antagonist compounds. A receptor antagonist is a substance which binds receptors and inactivates them. Thus, in one embodiment, the SARM compounds of the present invention are useful in binding to and inactivating steroidal hormone receptors. In one embodiment, the antagonist compound of the present invention is an antagonist which binds the androgen receptor. In another embodiment, the compound has high affinity for the androgen receptor.

[000136] In yet another embodiment, the SARM compounds of the present invention can be classified as partial AR agonist/antagonists. The SARMs are AR agonists in some tissues, to cause increased transcription of AR-responsive genes (e.g. muscle anabolic effect). In other tissues, these compounds serve as inhibitors at the AR to prevent agonistic effects of the native androgens.

[000137] Assays to determine whether the compounds of the present invention are AR agonists or antagonists are well known to a person skilled in the art. For example, AR agonistic activity can be determined by monitoring the ability of the SARM compounds to maintain and/or stimulate the growth of AR containing tissue such as prostate and seminal vesicles, as measured by weight. AR antagonistic activity can be determined by monitoring the ability of the SARM compounds to inhibit the growth of AR containing tissue.

[000138] The compounds of the present invention bind either reversibly or irreversibly to an androgen receptor. In one embodiment, the androgen receptor is an androgen receptor of a mammal. In another embodiment, the androgen receptor is an androgen receptor of a human. In one embodiment, the SARM compounds bind reversibly to the androgen receptor of a mammal, for example a human. Reversible binding of a compound to a receptor means that a compound can detach from the receptor after binding.

[000139] In another embodiment, the SARM compounds bind irreversibly to the androgen receptor of a mammal, for example a human. Thus, in one embodiment, the compounds of the present invention may contain a functional group (e.g. affinity label) that allows alkylation of the androgen receptor (i.e. covalent bond formation). Thus, in this case, the compounds are alkylating agents which bind irreversibly to the receptor and, accordingly, cannot be displaced by a steroid, such as the endogenous ligands DHT and testosterone. An "alkylating agent" is defined herein as an agent which alkylates (forms a covalent bond) with a cellular component, such as DNA, RNA or enzyme. It is a highly reactive chemical that introduces alkyl radicals into biologically active

molecules and thereby prevents their proper functioning. The alkylating moiety is an electrophilic group that interacts with nucleophilic moieties in cellular components.

[000140] According to one embodiment of the present invention, a method is provided for binding the SARM metabolites of the present invention to an androgen receptor by contacting the receptor with a SARM metabolite and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, under conditions effective to cause the selective androgen receptor modulator compound to bind the androgen receptor. The binding of the selective androgen receptor modulator compounds to the androgen receptor enables the compounds of the present invention to be useful as a male contraceptive and in a number of hormone therapies. The agonist compounds bind to and activate the androgen receptor. The antagonist compounds bind to and inactivate the androgen receptor. Binding of the agonist or antagonist compounds is either reversible or irreversible.

[000141] According to one embodiment of the present invention, a method is provided for suppressing spermatogenesis in a subject by contacting an androgen receptor of the subject with a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to bind the selective androgen receptor modulator compound to the androgen receptor and suppress spermatogenesis.

[000142] In another embodiment, the present invention provides a method of contraception in a male subject, comprising the step of administering to the subject a SARM compound of the present invention, and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to suppress sperm production in the subject, thereby effecting contraception in the subject.

[000143] According to another embodiment of the present invention, a method is provided for hormonal therapy in a patient (i.e., one suffering from an androgen-dependent condition) which includes contacting an androgen receptor of a patient with a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to bind the selective androgen receptor modulator compound to the androgen receptor and effect a change in an androgen-dependent condition.

[000144] According to another embodiment of the present invention, a method is provided for hormonal replacement therapy in a patient which includes contacting an androgen receptor of a patient with a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to bind the selective androgen receptor modulator compound to the androgen receptor and effect a change in an androgen-dependent condition.

[000145] According to another embodiment of the present invention, a method is provided for treating a subject having a hormone related condition which includes administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to bind the SARM compound to the androgen receptor and effect a change in an androgen-dependent condition.

[000146] Androgen-dependent conditions which may be treated according to the present invention include those conditions which are associated with aging, such as hypogonadism, sarcopenia, erythropoiesis, osteoporosis, and any other conditions determined to be dependent upon low androgen (e.g., testosterone) levels.

[000147] According to another embodiment of the present invention, a method is provided for treating a subject suffering from prostate cancer, comprising the step of administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to treat prostate cancer in the subject.

[000148] According to another embodiment of the present invention, a method is provided for preventing prostate cancer in a subject, comprising the step of administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to prevent prostate cancer in the subject.

[000149] According to another embodiment of the present invention, a method is provided for delaying the progression of prostate cancer in a subject suffering from prostate cancer, comprising the step of administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to delay the progression of prostate cancer in the subject.

[000150] According to another embodiment of the present invention, a method is provided for preventing the recurrence of prostate cancer in a subject suffering from prostate cancer, comprising the step of administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to prevent the recurrence of prostate cancer in the subject.

[000151] According to another embodiment of the present invention, a method is provided for treating the recurrence of prostate cancer in a subject suffering from prostate

cancer, comprising the step of administering to the subject a SARM metabolite of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to treat the recurrence of prostate cancer in the subject.

[000152] Furthermore, stimulation of the Androgen Receptor stimulates the production of tears, and thus the SARM compounds of the present invention may be used to treat dry eye conditions. Therefore, according to another embodiment of the present invention, a method is provided for treating a dry eye condition in a subject suffering from dry eyes, comprising the step of administering to said subject the selective androgen receptor modulator compound of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to treat dry eyes in the subject.

[000153] According to another embodiment of the present invention, a method is provided for preventing a dry eye condition in a subject, comprising the step of administering to said subject the selective androgen receptor modulator compound of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to prevent dry eyes in the subject.

[000154] In another embodiment, the present invention provides a a method of inducing apoptosis in a cancer cell, comprising the step of contacting the cell with with the selective androgen receptor modulator compound of the present invention and/or its analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, metabolite, polymorph, crystal or any combination thereof, in an amount effective to induce apoptosis in said cancer cell.

[000155] As defined herein, "contacting" means that the SARM metabolite of the present invention is introduced into a sample containing the enzyme in a test tube, flask,

tissue cultureor CHip, array, plate, microplate, capillary, or the like, and incubated at a temperature and time sufficient to permit binding of the SARM to the enzyme. Methods for contacting the samples with the SARM or other specific binding components are known to those skilled in the art and may be selected depending on the type of assay protocol to be run. Incubation methods are also standard and are known to those skilled in the art.

[000156] In another embodiment, the term "contacting" means that the SARM metabolite of the present invention is introduced into a subject receiving treatment, and the SARM compound is allowed to come in contact with the androgen receptor *in vivo*.

[000157] The term "libido, as used herein, means sexual desire.

[000158] The term "erectile", as used herein, means capable of being erected. An erectile tissue is a tissue, which is capable of being greatly dilated and made rigid by the distension of the numerous blood vessels which it contains.

[000159] "Hypogonadism" is a condition resulting from or characterised by abnormally decreased functional activity of the gonads, with retardation of growth and sexual development. "Osteopenia" refers to decreased calcification or density of bone. This is a term which encompasses all skeletal systems in which such a condition is noted.

[000160] "Osteoporosis" refers to a thinning of the bones with reduction in bone mass due to depletion of calcium and bone protein. Osteoporosis predisposes a person to fractures, which are often slow to heal and heal poorly. Unchecked osteoporosis can lead to changes in posture, physical abnormality, and decreased mobility.

[000161] "BPH (benign prostate hyperplasia)" is a nonmalignant enlargement of the prostate gland, and is the most common non-malignant proliferative abnormality found in any internal organ and the major cause of morbidity in the adult male. BPH occurs in over 75% of men over 50 years of age, reaching 88% prevalence by the ninth decade. BPH frequently results in a gradual squeezing of the portion of the urethra

which traverses the prostate (prostatic urethra). This causes patients to experience a frequent urge to urinate because of incomplete emptying of the bladder and urgency of urination. The obstruction of urinary flow can also lead to a general lack of control over urination, including difficulty initiating urination when desired, as well as difficulty in preventing urinary flow because of the inability to empty urine from the bladder, a condition known as overflow urinary incontinence, which can lead to urinary obstruction and to urinary failure.

[000162] "Cognition" refers to the process of knowing, specifically the process of being aware, knowing, thinking, learning and judging. Cognition is related to the fields of psychology, linguistics, computer science, neuroscience, mathematics, ethology and philosophy. The term "mood" refers to a temper or state of the mind. As contemplated herein, alterations means any change for the positive or negative, in cognition and/or mood.

[000163] The term "depression" refers to an illness that involves the body, mood and thoughts, that affects the way a person eats, sleeps and the way one feels about oneself, and thinks about things. The signs and symptoms of depression include loss of interest in activities, loss of appetite or overeating, loss of emotional expression, an empty mood, feelings of hopelessness, pessimism, guilt or helplessness, social withdrawal, fatigue, sleep disturbances, trouble concentrating, remembering, or making decisions, restlessness, irritability, headaches, digestive disorders or chronic pain.

[000164] The term "hair loss", medically known as alopecia, refers to baldness as in the very common type of male-pattern baldness. Baldness typically begins with patch hair loss on the scalp and sometimes progresses to complete baldness and even loss of body hair. Hair loss affects both males and females.

[000165] "Anemia" refers to the condition of having less than the normal number of red blood cells or less than the normal quantity of hemoglobin in the blood. The oxygen-carrying capacity of the blood is, therefore, decreased. Persons with anemia may feel tired and fatigue easily, appear pale, develop palpitations and become usually short

of breath. Anemia is caused by four basic factors: a) hemorrhage (bleeding); b) hemolysis (excessive destruction of red blood cells); c) underproduction of red blood cells; and d) not enough normal hemoglobin. There are many forms of anemia, including aplastic anemia, benzene poisoning, Fanconi anemia, hemolytic disease of the newborn, hereditary spherocytosis, iron deficiency anemia, osteopetrosis, pernicious anemia, sickle cell disease, thalassemia, myelodysplastic syndrome, and a variety of bone marrow diseases. As contemplated herein, the SARM compounds of the present invention are useful in preventing and/or treating any one or more of the above-listed forms of anemia.

[000166] "Obesity" refers to the state of being well above one's normal weight. Traditionally, a person is considered to be obese if they are more than 20 percent over their ideal weight. Obesity has been more precisely defined by the National Institute of Health (NIH) as a Body to Mass Index (BMI) of 30 or above. Obesity is often multifactorial, based on both genetic and behavioral factors. Overweight due to obesity is a significant contributor to health problems. It increases the risk of developing a number of diseases including: Type 2 (adult-onset) diabetes; high blood pressure (hypertension); stroke (cerebrovascular accident or CVA); heart attack (myocardial infarction or MI); heart failure (congestive heart failure); cancer (certain forms such as cancer of the prostate and cancer of the colon and rectum); gallstones and gallbladder disease (cholecystitis); Gout and gouty arthritis; osteoarthritis (degenerative arthritis) of the knees, hips, and the lower back; sleep apnea (failure to breath normally during sleep, lowering blood oxygen); and Pickwickian syndrome (obesity, red face, underventilation and drowsiness). As contemplated herein, the term "obesity" includes any one of the above-listed obesity-related conditions and diseases. Thus the SARM compounds of the present invention are useful in preventing and/or treating obesity and any one or more of the above-listed obesity-related conditions and diseases.

[000167] "Prostate cancer" is one of the most frequently occurring cancers among men in the United States, with hundreds of thousands of new cases diagnosed each year. Over sixty percent of newly diagnosed cases of prostate cancer are found to be pathologically advanced, with no cure and a dismal prognosis. One third of all men over 50 years of age have a latent form of prostate cancer that may be activated into the life-

threatening clinical prostate cancer form. The frequency of latent prostatic tumors has been shown to increase substantially with each decade of life from the 50s (5.3-14%) to the 90s (40-80%). The number of people with latent prostate cancer is the same across all cultures, ethnic groups, and races, yet the frequency of clinically aggressive cancer is markedly different. This suggests that environmental factors may play a role in activating latent prostate cancer.

PHARMACEUTICAL COMPOSITIONS

[000168] The treatment methods of the present invention comprise, in one embodiment, administering a pharmaceutical preparation comprising the SARM compound, e.g. SARM metabolite of the present invention. In another embodiment, the treatment methods of the present invention comprise administering a pharmacetucial preparation comprising an analog, derivative, isomer, metabolite, pharmaceutically acceptable salt, pharmaceutical product, hydrate, N-oxide, polymorph, crystal or any combination thereof of the SARM compound; and a pharmaceutically acceptable carrier.

[000169] As used herein, "pharmaceutical composition" means a composition comprising an “effective amount” of the active ingredient, i.e. the SARM compound, together with a pharmaceutically acceptable carrier or diluent.

[000170] An "effective amount" as used herein refers to that amount which provides a therapeutic effect for a given condition and administration regimen. An "effective amount" of the SARM compounds as used herein can be in the range of 1-500 mg/day. In one embodiment the dosage is in the range of 1-100 mg/day. In another embodiment the dosage is in the range of 100-500 mg/day. In another embodiment the dosage is in a range of 45-60 mg/day. In another embodiment the dosage is in the range of 15-25 mg/day. In another embodiment the dosage is in the range of 55-65 mg/day. In another embodiment the dosage is in the range of 45-60 mg/day. The SARM compounds can be administered daily, in single dosage forms containing the entire amount of daily dose, or can be administered daily in multiple doses such as twice daily or three times

daily. The SARM compounds can also be administered intermittently, for example every other day, 3 days a week, four days a week, five days a week and the like.

[000171] As used herein, the term "treating" includes preventative as well as disorder remitative treatment. As used herein, the terms "reducing", "suppressing" and "inhibiting" have their commonly understood meaning of lessening or decreasing. As used herein, the term "facilitating" is giving its commonly understood meaning of increasing the rate. As used herein, the term "promoting" is given its commonly understood meaning of increasing. As used herein, the term "progression" means increasing in scope or severity, advancing, growing or becoming worse.

[000172] As used herein, the term "administering" refers to bringing a subject in contact with a SARM compound of the present invention. As used herein, administration can be accomplished *in vitro*, i.e. in a test tube, or *in vivo*, i.e. in cells or tissues of living organisms, for example humans. In one embodiment, the present invention encompasses administering the compounds of the present invention to a subject. In one embodiment, the subject is a mammalian subject. In another embodiment, the subject is a human.

[000173] The pharmaceutical compositions containing the SARM agent can be administered to a subject by any method known to a person skilled in the art, such as parenterally, paracancerally, transmucosally, transdermally, intramuscularly, intravenously, intradermally, subcutaneously, intraperitonealy, intraventricularly, intracranially, intravaginally or intratumorally.

[000174] In one embodiment, the pharmaceutical compositions are administered orally, and are thus formulated in a form suitable for oral administration, i.e. as a solid or a liquid preparation. Suitable solid oral formulations include tablets, capsules, pills, granules, pellets and the like. Suitable liquid oral formulations include solutions, suspensions, dispersions, emulstions, oils and the like. In one embodiment of the present invention, the SARM compounds are formulated in a capsule. In accordance with this embodiment, the compositions of the present invention comprise in addition to the SARM active Compound B nd the inert carrier or diluent, a hard gelating capsule.

[000175] Further, in another embodiment, the pharmaceutical compositions are administered by intravenous, intraarterial, or intramuscular injection of a liquid preparation. Suitable liquid formulations include solutions, suspensions, dispersions, emulsions, oils and the like. In one embodiment, the pharmaceutical compositions are administered intravenously, and are thus formulated in a form suitable for intravenous administration. In another embodiment, the pharmaceutical compositions are administered intraarterially, and are thus formulated in a form suitable for intraarterial administration. In another embodiment, the pharmaceutical compositions are administered intramuscularly, and are thus formulated in a form suitable for intramuscular administration.

[000176] Further, in another embodiment, the pharmaceutical compositions are administered topically to body surfaces, and are thus formulated in a form suitable for topical administration. Suitable topical formulations include gels, ointments, creams, lotions, drops and the like. For topical administration, the SARM agents or their physiologically tolerated derivatives such as salts, esters, N-oxides, and the like are prepared and applied as solutions, suspensions, or emulsions in a physiologically acceptable diluent with or without a pharmaceutical carrier.

[000177] Further, in another embodiment, the pharmaceutical compositions are administered as a suppository, for example a rectal suppository or a urethral suppository. Further, in another embodiment, the pharmaceutical compositions are administered by subcutaneous implantation of a pellet. In a further embodiment, the pellet provides for controlled release of SARM agent over a period of time.

[000178] In another embodiment, the active compound can be delivered in a vesicle, in particular a liposome (see Langer, Science 249:1527-1533 (1990); Treat et al., in Liposomes in the Therapy of Infectious Disease and Cancer, Lopez- Berestein and Fidler (eds.), Liss, New York, pp. 353-365 (1989); Lopez-Berestein, ibid., pp. 317-327; see generally ibid).

[000179] As used herein "pharmaceutically acceptable carriers or diluents" are well known to those skilled in the art. The carrier or diluent may be a solid carrier or diluent for solid formuations, a liquid carrier or diluent for liquid formulations, or mixtures thereof.

[000180] Solid carriers/diluents include, but are not limited to, a gum, a starch (e.g. corn starch, pregeletanized starch), a sugar (e.g., lactose, mannitol, sucrose, dextrose), a cellulosic material (e.g. microcrystalline cellulose), an acrylate (e.g. polymethylacrylate), calcium carbonate, magnesium oxide, talc, or mixtures thereof.

[000181] For liquid formulations, pharmaceutically acceptable carriers may be aqueous or non-aqueous solutions, suspensions, emulsions or oils. Examples of non-aqueous solvents are propylene glycol, polyethylene glycol, and injectable organic esters such as ethyl oleate. Aqueous carriers include water, alcoholic/aqueous solutions, emulsions or suspensions, including saline and buffered media. Examples of oils are those of petroleum, animal, vegetable, or synthetic origin, for example, peanut oil, soybean oil, mineral oil, olive oil, sunflower oil, and fish-liver oil.

[000182] Parenteral vehicles (for subcutaneous, intravenous, intraarterial, or intramuscular injection) include sodium chloride solution, Ringer's dextrose, dextrose and sodium chloride, lactated Ringer's and fixed oils. Intravenous vehicles include fluid and nutrient replenishers, electrolyte replenishers such as those based on Ringer's dextrose, and the like. Examples are sterile liquids such as water and oils, with or without the addition of a surfactant and other pharmaceutically acceptable adjuvants. In general, water, saline, aqueous dextrose and related sugar solutions, and glycols such as propylene glycols or polyethylene glycol are preferred liquid carriers, particularly for injectable solutions. Examples of oils are those of petroleum, animal, vegetable, or synthetic origin, for example, peanut oil, soybean oil, mineral oil, olive oil, sunflower oil, and fish-liver oil.

[000183] In addition, the compositions may further comprise binders (e.g. acacia, cornstarch, gelatin, carbomer, ethyl cellulose, guar gum, hydroxypropyl cellulose,

hydroxypropyl methyl cellulose, povidone), disintegrating agents (e.g. cornstarch, potato starch, alginic acid, silicon dioxide, croscarmelose sodium, crospovidone, guar gum, sodium starch glycolate), buffers (e.g., Tris-HCI., acetate, phosphate) of various pH and ionic strength, additives such as albumin or gelatin to prevent absorption to surfaces, detergents (e.g., Tween 20, Tween 80, Pluronic F68, bile acid salts), protease inhibitors, surfactants (e.g. sodium lauryl sulfate), permeation enhancers, solubilizing agents (e.g., glycerol, polyethylene glycerol), anti-oxidants (e.g., ascorbic acid, sodium metabisulfite, butylated hydroxyanisole), stabilizers (e.g. hydroxypropyl cellulose, hyroxypropylmethyl cellulose), viscosity increasing agents(e.g. carbomer, colloidal silicon dioxide, ethyl cellulose, guar gum), sweetners (e.g. aspartame, citric acid), preservatives (e.g., Thimerosal, benzyl alcohol, parabens), lubricants (e.g. stearic acid, magnesium stearate, polyethylene glycol, sodium lauryl sulfate), flow-aids (e.g. colloidal silicon dioxide), plasticizers (e.g. diethyl phthalate, triethyl citrate), emulsifiers (e.g. carbomer, hydroxypropyl cellulose, sodium lauryl sulfate), polymer coatings (e.g., poloxamers or poloxamines), coating and film forming agents (e.g. ethyl cellulose, acrylates, polymethacrylates) and/or adjuvants.

[000184] In one embodiment, the pharmaceutical compositions provided herein are controlled release compositions, i.e. compositions in which the SARM compound is released over a period of time after administration. Controlled or sustained release compositions include formulation in lipophilic depots (e.g. fatty acids, waxes, oils). In another embodiment, the composition is an immediate release composition, i.e. a composition in which all of the SARM compound is released immediately after administration.

[000185] In yet another embodiment, the pharmaceutical composition can be delivered in a controlled release system. For example, the agent may be administered using intravenous infusion, an implantable osmotic pump, a transdermal patch, liposomes, or other modes of administration. In one embodiment, a pump may be used (see Langer, supra; Sefton, CRC Crit. Ref. Biomed. Eng. 14:201 (1987); Buchwald et al., Surgery 88:507 (1980); Saudek et al., N. Engl. J. Med. 321:574 (1989). In another embodiment, polymeric materials can be used. In yet another embodiment, a controlled release system can be placed in proximity to the therapeutic target, i.e., the brain, thus

requiring only a fraction of the systemic dose (see, e.g., Goodson, in Medical Applications of Controlled Release, supra, vol. 2, pp. 115-138 (1984). Other controlled release systems are discussed in the review by Langer (Science 249:1527-1533 (1990).

[000186] The compositions may also include incorporation of the active material into or onto particulate preparations of polymeric compounds such as polylactic acid, polglycolic acid, hydrogels, etc, or onto liposomes, microemulsions, micelles, unilamellar or multilamellar vesicles, erythrocyte ghosts, or spheroplasts.) Such compositions will influence the physical state, solubility, stability, rate of *in vivo* release, and rate of *in vivo* clearance.

[000187] Also comprehended by the invention are particulate compositions coated with polymers (e.g. poloxamers or poloxamines) and the compound coupled to antibodies directed against tissue-specific receptors, ligands or antigens or coupled to ligands of tissue-specific receptors.

[000188] Also comprehended by the invention are compounds modified by the covalent attachment of water-soluble polymers such as polyethylene glycol, copolymers of polyethylene glycol and polypropylene glycol, carboxymethyl cellulose, dextran, polyvinyl alcohol, polyvinylpyrrolidone or polyproline. The modified compounds are known to exhibit substantially longer half-lives in blood following intravenous injection than do the corresponding unmodified compounds (Abuchowski et al., 1981; Newmark et al., 1982; and Katre et al., 1987). Such modifications may also increase the compound's solubility in aqueous solution, eliminate aggregation, enhance the physical and chemical stability of the compound, and greatly reduce the immunogenicity and reactivity of the compound. As a result, the desired *in vivo* biological activity may be achieved by the administration of such polymer-Compound B bducts less frequently or in lower doses than with the unmodified compound.

[000189] The preparation of pharmaceutical compositions which contain an active component is well understood in the art, for example by mixing, granulating, or tablet-forming processes. The active therapeutic ingredient is often mixed with excipients

which are pharmaceutically acceptable and compatible with the active ingredient. For oral administration, the SARM agents or their physiologically tolerated derivatives such as salts, esters, N-oxides, and the like are mixed with additives customary for this purpose, such as vehicles, stabilizers, or inert diluents, and converted by customary methods into suitable forms for administration, such as tablets, coated tablets, hard or soft gelatin capsules, aqueous, alcoholic or oily solutions. For parenteral administration, the SARM agents or their physiologically tolerated derivatives such as salts, esters, N-oxides, and the like are converted into a solution, suspension, or emulsion, if desired with the substances customary and suitable for this purpose, for example, solubilizers or other.

[000190] An active component can be formulated into the composition as neutralized pharmaceutically acceptable salt forms. Pharmaceutically acceptable salts include the acid addition salts (formed with the free amino groups of the polypeptide or antibody molecule), which are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric, mandelic, and the like. Salts formed from the free carboxyl groups can also be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium, or ferric hydroxides, and such organic bases as isopropylamine, trimethylamine, 2-ethylamino ethanol, histidine, procaine, and the like.

[000191] For use in medicine, the salts of the SARM will be pharmaceutically acceptable salts. Other salts may, however, be useful in the preparation of the compounds according to the invention or of their pharmaceutically acceptable salts. Suitable pharmaceutically acceptable salts of the compounds of this invention include acid addition salts which may, for example, be formed by mixing a solution of the Compound B ccording to the invention with a solution of a pharmaceutically acceptable acid such as hydrochloric acid, sulphuric acid, methanesulphonic acid, fumaric acid, maleic acid, succinic acid, acetic acid, benzoic: acid, oxalic acid, citric acid, tartaric acid, carbonic acid or phosphoric acid.

[000192] In one embodiment, the methods of the present invention comprise administering a SARM compound as the sole active ingredient. However, also

encompassed within the scope of the present invention are methods of a) male contraception; b) treatment of a variety of hormone-related conditions, for example conditions associated with Androgen Decline in Aging Male (ADAM); c) treatment of conditions associated with Androgen Decline in Female (ADIF); d) treatment and/or prevention of acute and/or chronic muscular wasting conditions; e) preventing and/or treating dry eye conditions; f) oral androgen replacement therapy; g) decreasing the incidence of, halting or causing a regression of prostate cancer; andr h) inducing apoptosis in a cancer cell as disclosed herein, which comprise administering the SARM compounds in combination with one or more therapeutic agents. These agents include, but are not limited to: LHRH analogs, reversible antiandrogens, antiestrogens, anticancer drugs, 5-alpha reductase inhibitors, aromatase inhibitors, progestins, or agents acting through other nuclear hormone receptors.

[000193] Thus, in one embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator metabolite, in combination with an LHRH analog. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with a reversible antiandrogen. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with an antiestrogen. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with an anticancer drug. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with a 5-alpha reductase inhibitor. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with an aromatase inhibitor. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a selective androgen receptor modulator compound, in combination with a progestin. In another embodiment, the present invention provides compositions and pharmaceutical compositions comprising a

selective androgen receptor modulator compound, in combination with an agent acting through other nuclear hormone receptors.

[000194] The following examples are presented in order to more fully illustrate the preferred embodiments of the invention. They should in no way be construed, however, as limiting the broad scope of the invention.

EXPERIMENTAL DETAILS SECTION

EXAMPLE 1

Nonsteroidal Ligands with Androgenic and Anabolic Activity

[000195] The SARM compounds provided herein were designed, synthesized and evaluated for in-vitro and in-vivo pharmacologic activity. The in-vitro androgen receptor binding affinity and ability to maintain androgen dependent tissue growth in castrated animals was studied. Androgenic activity was monitored as the ability of the SARM compounds to maintain and/or stimulate the growth of the prostate and seminal vesicles, as measured by weight. Anabolic activity was monitored as the ability of the SARM compounds to maintain and/or stimulate the growth of the levator ani muscle, as measured by weight.

Synthetic Procedures

[000196] **(2R)-1-Methacryloylpyrrolidin–2-carboxylic Acid (R-129).** D-Proline (**R-128**, 14.93 g, 0.13 mol) was dissolved in 71 mL of 2 N NaOH and cooled in an ice bath; the resulting alkaline solution was diluted with acetone (71 mL). An acetone solution (71 mL) of metacryloly chloride **127** (13.56 g, 0.13 mol) and 2N NaOH solution (71 mL) were simultaneously added over 40 min to the aqueous solution of D-proline in an ice bath. The pH of the mixture was kept at 10-11°C during the addition of the metacryloly chloride. After stirring (3 h, room temperature), the mixture was evaporated in vacuo at a temperature at 35-45 °C to remove acetone. The resulting solution was washed with ethyl ether and was acidified to pH 2 with concentrated HCl. The acidic

mixture was saturated with NaCl and was extracted with EtOAc (100 mL x 3). The combined extracts were dried over Na_2SO_4, filtered through Celite, and evaporated in vacuo to give the crude product as a colorless oil. Recrystallization of the oil from ethyl ether and hexanes afforded 16.2 (68%) of the desired compound as colorless crystals: mp 102-103 °C (lit. [214] mp 102.5-103.5 °C); the NMR spectrum of this compound demonstrated the existence of two rotamers of the title compound. ^1H NMR (300 MHz, DMSO-d_6) δ 5.28 (s) and 5.15 (s) for the first rotamer, 5.15 (s) and 5.03 (s) for the second rotamer (totally 2H for both rotamers, vinyl CH_2), 4.48-4.44 for the first rotamer, 4.24-4.20 (m) for the second rotamer (totally 1H for both rotamers, CH at the chiral canter), 3.57-3.38 (m, 2H, CH_2), 2.27-2.12 (1H, CH), 1.97-1.72 (m, 6H, CH_2, CH, Me); ^{13}C NMR (75 MHz, DMSO-d_6) δ for major rotamer 173.3, 169.1, 140.9, 116.4, 58.3, 48.7, 28.9, 24.7, 19.5: for minor rotamer 174.0, 170.0, 141.6, 115.2, 60.3, 45.9, 31.0, 22.3, 19.7; IR (KBr) 3437 (OH), 1737 (C=O), 1647 (CO, COOH), 1584, 1508, 1459, 1369, 1348, 1178 cm^{-1}; $[\alpha]_D^{26}$ +80.8° (c = 1, MeOH); Anal. Calcd. for $C_9H_{13}NO_3$: C 59.00, H 7.15, N 7.65. Found: C 59.13, H 7.19, N 7.61.

[000197] **(3R,8aR)-3-Bromomethyl-3-methyl-tetrahydro-pyrrolo[2,1c] [1,4] oxazine-1,4-dione (R, R-130)**. A solution of NBS (23.5g, 0.132 mol) in 100 mL of DMF was added dropwise to a stirred solution of compound **R-129** (16.1g, 88 mmol) in 70 mL of DMF under argon at room temperature, and the resulting mixture was stirred 3 days. The solvent was removed in vacuo, and a yellow solid was precipitated. The solid was suspended in water, stirred overnight at room temperature, filtered, and dried to give 18.6 (81%) (smaller weight when dried ~ 34%) of the title compound as a yellow solid: mp 152-154 °C (lit. [214] mp 107-109 °C for the S-isomer); ^1H NMR (300 MHz, DMSO-d_6) δ 4.69 (dd, J = 9.6 Hz, J = 6.7 Hz, 1H, CH at the chiral center), 4.02 (d, J = 11.4 Hz, 1H, CHH_a), 3.86 (d, J = 11.4 Hz, 1H, CHH_b), 3.53-3.24 (m, 4H, CH_2), 2.30-2.20 (m, 1H, CH), 2.04-1.72 (m, 3H, CH_2 and CH), 1.56 (s, 2H, Me); ^{13}C NMR (75 MHz, DMSO-d_6) δ 167.3, 163.1, 83.9, 57.2, 45.4, 37.8, 29.0, 22.9, 21.6; IR (KBr) 3474, 1745 (C=O), 1687 (C=O), 1448, 1377, 1360, 1308, 1227, 1159, 1062cm^{-1}; $[\alpha]_D^{26}$ +124.5 ° (c = 1.3, chloroform); Anal. Calcd. for $C_9H_{12}BrNO_3$: C 41.24, H 4.61, N 5.34. Found: C 41.46, H 4.64, N 5.32.

[000198] **(2R)-3-Bromo-2-hydroxy-2-methylpropanoic Acid (R-131)**. A mixture of bromolactone **R-130** (18.5g, 71 mmol) in 300 mL of 24% HBr was heated at reflux for 1 h. The resulting solution was diluted with brine (200 mL), and was extracted with ethyl acetate (100 mL x 4). The combined extracts were washed with saturated $NaHCO_3$ (100 mL x 4). The aqueous solution was acidified with concentrated HCl to pH = 1, which, in turn, was extracted with ethyl acetate (100 mL x 4). The combined organic solution was dried over Na_2SO_4, filtered through Celite, and evaporated in vacuo to dryness. Recrystallization from toluene afforded 10.2 g (86%) of the desired compound as colorless crystals: mp 107-109 °C (lit. [214] mp 109-113 °C for the S-isomer); ^{1}H NMR (300 MHz, DMSO-d_6) δ 3.63 (d, J = 10.1 Hz, 1H, CHH_a), 3.52 (d, J = 10.1 Hz, 1H, CHH_b), 1.35 (s, 3H, Me); IR (KBr) 3434 (OH), 3300-2500 (COOH), 1730 (C=O), 1449, 1421, 1380, 1292, 1193, 1085 cm^{-1}; $[\alpha]_D^{26}$ +10.5° (c = 2.6, MeOH); Anal. Calcd. for $C_4H_7BrO_3$: C 26.25, H 3.86. Found: C 26.28, H 3.75.

[000199] **N-[4-Nitro-3-(trifluoromethyl)phenyl]-(2R)-3-bromo-2-hydroxy-2-methylpropanamide (R-132)**. Thionyl chloride (8.6 g, 72 mmol) was added dropwise under argon to a solution of bromoacid **R-131** (11.0 g, 60 mmol) in 70 mL of DMA at –5 to –10 °C. The resulting mixture was stirred for 2 h under the same conditions. A solution of 4-nitro-3-trifluoromethyl-aniline (12.4 g, 60 mmol) in 80 mL of DMA was added dropwise to the above solution, and the resulting mixture was stirred overnight at room temperature. The solvent was removed on Rotavapor using high vacuum oil pump; the residue was diluted with saturated $NaHCO_3$ solution, and extracted with ethyl ether (100 mL x 3). Combined extracts were dried over anhydrous Na_2SO_4, filtered through Celite, and purified by flash chromatography on silica gel, using methylene chloride as eluent to afford 18.0 g (80%) of the desired compound: mp 98-100 °C (R_f = 0.2 , silica gel, CH_2Cl_2); ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.54 (s, 1H, NH), 8.54 (d, J = 2.1 Hz, 1H, ArH), 8.34 (dd, J = 9.0 Hz, J = 2.1 Hz, 1H, ArH), 8.18 (d, J = 9.0 Hz, 1H, ArH), 6.37 (s, 1H, OH), 3.82 (d, J = 10.4 Hz, 1H, CHH_a), 3.58 (d, J = 10.4 Hz, 1H, CHH_b), 1.48 (s, 3H, Me); ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.6 (C=O), 143.0, 127.2, 123.2, 122.6 (q, J = 33.0 Hz), 122.0 (q, J = 271.5 Hz), 118.3 (q, J = 6.0 Hz), 74.4, 41.4, 24.9; IR (KBr) 3344 (OH), 1680 (C=O), 1599, 1548 (C=C, Ar), 1427, 1363, 1161 cm^{-1}; MS (ESI): m/z

370.8 $(M)^+$; Anal. Calcd. for $C_{11}H_{10}BrN_2O_4$: C 35.60, H 2.72, N 7.55. Found: C 35.68, H 2.72, N 7.49.

[000200] **N-[4-nitro-3-trifluoromethyl)phenyl]-(2S)-3-[4-(acetylamino) phen oxy]-2-hydroxy-2-methylpropanamide (S-147, Compound IV).** The title compound was prepared from compound **R-132** (0.37 g, 1.0 mmol), 4-acetamidophenol (0.23 g, 1.5 mmol) K_2CO_3 (0.28 g, 2.0 mmol), and 10% of benzyltributylammonium chloride as a phase transfer catalyst in 20 mL of methyl ethyl ketone was heated at reflux overnight under argon. The reaction was followed by TLC, the resulting mixture was filtered through Celite, and concentrated in vacuo to dryness. Purification by flash column chromatography on silica gel (hexanes-ethyl acetate, 3:1) yielded 0.38 g (86%) (R_f = 0.18 hexanes-ethyl acetate, 3:1) of the desired compound as a light yellow powder: mp 70-74 °C; The solid can be recrystalized from ethyl acetate and hexane); ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.62 (s, 1H, NH), 9.75 (s, 1H, NH), 8.56 (d, J = 1.9 Hz, 1H, ArH), 8.36 (dd, J = 9.1 Hz, J = 1.9 Hz, 1H, ArH), 8.18 (d, J = 9.1 Hz, 1H, ArH), 7.45-7.42 (m, 2H, ArH), 6.85-6.82 (m, 2H, ArH), 6.25 (s, 1H, OH), 4.17 (d, J = 9.5 Hz, 1H, CHH_a), 3.94 (d, J = 9.5 Hz, 1H, CHH_b), 1.98 (s, 3H, Me), 1.43 (s, 3H, Me); ^{13}C NMR (75 MHz, DMSO-d_6) δ 174.6 (C=O), 167.7, 154.2, 143.3, 141.6, 132.8, 127.4, 123.0, 122.7 (q, J = 33.0 Hz), 122.1 (q, J = 271.5 Hz), 120.1, 118.3 (q, J = 6.0 Hz), 114.6, 74.9, 73.8, 23.8, 23.0; IR (KBr) 3364 (OH), 1668 (C=O), 1599, 1512 (C=C, Ar), 1457, 1415, 1351, 1323, 1239, 1150 1046 cm^{-1}; MS (ESI): m/z 464.1 $(M+Na)^+$; Anal. Calcd. for $C_{19}H_{18}F_3N_3O_6$: C 51.71, H 4.11, N 9.52. Found: C 52.33, H 4.40, N 9.01.

[000201] The synthesis of the various SARM compounds, utilizes the common intermediate that is the final reaction step. Bromo-intermediates are used which allow various phenolic compounds to displace the bromide to give the desired ether product. Bromohydrin was converted to an epoxide and to open the epoxide to give the same desired ether product.

[000202] The in-vitro activity of the SARM compounds, specifically Compound IV, demonstrated high androgen receptor binding affinity (Ki = 7.5 nM). Animal studies with the SARM compounds, specifically Compound IV, demonstrated that it is a potent

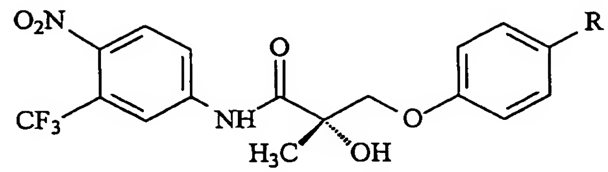
androgenic and anabolic nonsteroidal agent. Four groups of rats were used for these studies: (1) intact controls, (2) castrated controls, (3) castrated animals treated with testosterone propionate (100 μg/day), and (4) castrated animals treated with Compound IV (1000 μg/day). Testosterone and Compound IV were delivered at a constant rate for 14 days via subcutaneous osmotic pumps.

[000203] The results of these studies are shown in Figure 1. Castration significantly reduced the weight of androgenic (e.g., prostate and seminal vesicles) and anabolic (e.g., levator ani muscle) tissues, but had little effect on animal body weight (BW). Treatment of castrated animals with testosterone propionate or Compound IV maintained the weight of androgenic tissues to the same degree. Compound IV had similar androgenic activity as testosterone propionate (i.e., the prostate and seminal vesicle weights were the same), but much greater efficacy as an anabolic agent. Compound IV showed greater anabolic activity than testosterone propionate at the doses tested (i.e., the levator ani muscle maintained the same weight as intact control animals and was greater than that observed for testosterone). The experiments presented herein are the first in-vivo results which demonstrate tissue-selective androgenic and anabolic activity (i.e., differing androgenic and anabolic potency) of a nonsteroidal ligand for the androgen receptor.

EXAMPLE 2

Nonsteroidal Ligands with Androgenic and Anabolic Activity

[000204] The in-vivo efficacy and acute toxicity of four novel nonsteroidal androgens (compounds III, IV, VI and VII) in rats was examined. In-vitro assays established that these compounds bind the androgen receptor with very high affinity. The structures and names of the four compounds are presented below:



Compound III	R= F
Compound IV	R=$NHCOCH_3$
Compound VI	R=$COCH_3$
Compound VII	R=COC_2H_5

EXPERIMENTAL METHODS

[000205] Materials. The S-isomers of III, IV, VI and VII R-isomer of compound III were synthesized in accordance with the scheme as set forth in Figure 9. Testosterone propionate (TP), polyethylene glycol 300 (PEG300, reagent grade) and neutral buffered formalin (10% w/v) were purchased from Sigma Chemical Company (St Louis, MO). Alzet osmotic pumps (model 2002) were purchased from Alza Corp. (Palo Alto, CA).

[000206] *Animals.* Immature male Sprague-Dawley rats, weighing 90 to 100g, were purchased from Harlan Biosciences (Indianapolis, IN). The animals were maintained on a 12-hour light-dark cycle with food and water available *ad libitum*. The animal protocol was reviewed and approved by the Institutional Laboratory Animal Care and Use Committee.

[000207] *Study Design.* Rats were randomly distributed into twenty-nine (29) groups, with 5 animals per group. Treatment groups are described in Table 1. One day prior to the start of drug treatment, animals in groups 2 through 29 were individually removed from the cage, weighed and anesthetized with an intraperitoneal dose of ketamine/xylazine (87/13 mg/kg; approximately 1 mL per kg). When appropriately anesthetized (i.e., no response to toe pinch), the animals' ears were marked for identification purposes. Animals were then placed on a sterile pad and their abdomen and scrotum washed with betadine and 70% alcohol. The testes were removed via a midline

scrotal incision, with sterile suture being used to ligate supra-testicular tissue prior to surgical removal of each testis. The surgical wound site was closed with sterile stainless steel wound clips, and the site cleaned with betadine. The animals were allowed to recover on a sterile pad (until able to stand) and then returned to their cage.

[000208] Twenty-four hours later, animals in groups 2 through 29 were re-anesthetized with ketamine/xylazine, and an Alzet osmotic pump(s) (model 2002) was placed subcutaneouly in the scapular region. In this instance, the scapular region was shaved and cleaned (betadine and alcohol) and a small incision (1 cm) made using a sterile scalpel. The osmotic pump was inserted and the wound closed with a sterile stainless steel wound clip. Animals were allowed to recover and were returned to their cage. Osmotic pumps contained the appropriate treatment (designated in Table 1) dissolved in polyethylene glycol 300 (PEG300). Osmotic pumps were filled with the appropriate solution one day prior to implantation. Animals were monitored daily for signs of acute toxicity to drug treatment (e.g., lethargy, rough coat).

[000209] After 14 days of drug treatment, rats were anesthetized with ketamine/xylazine. Animals were then sacrificed by exsanguinations under anesthesia. A blood sample was collected by venipuncture of the abdominal aorta, and submitted for complete blood cell analysis. A portion of the blood was placed in a separate tube, centrifuged at 12,000g for 1 minute, and the plasma layer removed and frozen at –20°C. The ventral prostates, seminal vesicles, levator ani muscle, liver, kidneys, spleen, lungs, and heart were removed, cleared of extraneous tissue, weighed, and placed in vials containing 10% neutral buffered formalin. Preserved tissues were sent to GTx, Inc. for histopathological analysis.

[000210] For data analysis, the weights of all organs were normalized to body weight, and analyzed for any statistical significant difference by single-factor ANOVA. The weights of prostate and seminal vesicle were used as indexes for evaluation of androgenic activity, and the levator ani muscle weight was used to evaluate the anabolic activity.

RESULTS

[000211] The androgenic and anabolic activities the S isomers of compounds III, IV, VI and VII, and the R isomer of compound III were examined in a castrated rat model after 14 days of administration. Testosterone propionate, at increasing doses, was used as the positive control of anabolic and androgenic effects.

[000212] As shown in Figures 2 and 3, the weights of prostate, seminal vesicle, and levator ani muscle in castrated, vehicle-treated rats decreased significantly, due to the ablation of endogenous androgen production. Exogenous administration of testosterone propionate, an androgenic and anabolic steroid, increased the weights of prostate, seminal vesicle, and levator ani muscle in castrated rats in a dose-dependent manner. The R-isomer of compound III, and S-isomers of compounds VI and VII showed no effect on the weights of prostate, seminal vesicle, and levator ani muscle in castrated animals (data not shown). The S-isomers of Compound IV (Figure 2: V) and compound III (Figure 3: III) resulted in dose-dependent increases in prostate, seminal vesicle and levator ani muscle weights. Compared with testosterone propionate, Compound IV showed lower potency and intrinsic activity in increasing the weights of prostate and seminal vesicle, but a greater potency and intrinsic activity in increasing the weight of levator ani muscle. Particularly, Compound IV, at a dose as low as 0.3 mg/day, was able to maintain the levator ani muscle weight of castrated animals in the same level as that of intact animals. Thus, Compound IV is a potent nonsteroidal anabolic agent with less androgenic activity but more anabolic activity than testosterone propionate. This is a significant improvement over previous claims, in that this compound selectively stimulates muscle growth and other anabolic effects while having less effect on the prostate and seminal vesicles. This may be particularly relevant in aging men with concerns related to the development or progression of prostate cancer.

[000213] Compound III was less potent than Compound IV, but showed greater tissue selectivity (compare effects on the prostate and seminal vesicles in Figures 2 and 3). Compound III significantly increased levator ani muscle weights, but showed little to no ability to stimulate prostate and seminal vesicle growth (i.e., the prostate and seminal

vesicle weights were less than 20% of that observed in intact animals or in animals treated with testosterone propionate).

[000214] Results showed that none of the examined compounds produced significant effect on body weight or the weights of other organs (i.e., liver, kidneys, spleen, lungs and heart). Nor did any compound produce any signs of acute toxicity, as gauged by diagnostic hematology tests and visual examination of animals receiving treatments. Importantly, Compound IV did not suppress the production of luteinizing hormone (LH) or follicle stimulating hormone (FSH) at a dose of 0.3 mg/day (i.e., a dose that exhibited maximal anabolic effects).

[000215] In summary, Compound IV exhibited exceptional anabolic activity in animals by maintaining the weight of levator ani muscle after removal of endogenous androgen. This discovery represents major progress towards the development of therapeutically useful nonsteroidal androgens, and a major improvement (i.e., tissue selectivity and potency) over previous drugs in this class. Compound III and Compound IV showed selective anabolic activity in comparison with testosterone propionate, an androgenic and anabolic steroid. The tissue-selective activity is actually one of the advantages of nonsteroidal androgens in terms of anabolic-related applications.

[000216] Despite similarities in structure and in-vitro functional activity, the S-isomers of compounds III-IV and VI-VII exhibited profound differences in terms of their in-vivo activity. Compound IV the most efficacious androgenic and anabolic activity in animals, with the anabolic activity greater than that of testosterone propionate. Compound III showed a small degree of androgenic activity, but an anabolic activity comparable to testosterone propionate. In contrast, Compounds VI and VII failed to produce any androgenic or anabolic activity in-vivo.

[000217] These studies show the discovery of two members (III and IV) of a new class of selective androgen receptor modulators (SARMS) that demonstrate potent anabolic effects (e.g., muscle growth) with less androgenic activity (e.g., prostatic growth). This new class of drugs has several advantages over non-selective androgens,

including potential therapeutic applications in males and females for modulation of fertility, erythropoiesis, osteoporosis, sexual libido and in men with or at high risk for prostate cancer.

[000218] Further, Figures 7 and 8 demonstrate the effects of compound III and Compound IV on LH and FSH levels in rats. These results further demonstrate the novelty of these SARMs, due to their differential effects on these reproductive hormones, thus demonstrating the tissue-specific pharmacologic activity. In Figure 7, LH levels in castrated animals treated with TP and compound III were significantly lower than those of untreated animals (i.e., castrated controls) at doses greater than or equal to 0.3 mg/day. However, higher doses (i.e., 0.5 mg/day or higher) of Compound IV were required before significant decreases in LH levels were observed. Thus, Compound IV does not suppress LH levels at doses that are capable of eliciting maximal stimulation of levator ani muscle growth. In Figure 8, FSH levels in castrated animals treated with compound III were significantly lower than those of untreated animals (i.e., castrated controls) at doses of 0.5 mg/day or higher. Similarly, lower FSH levels were observed in animals treated with TP. However, only this difference was only significant at a dose of 0.75 mg/day. FSH levels in animals treated with Compound IV were not significantly different from those of untreated animals at any dose level tested. Thus, Compound IV does not suppress FSH levels at doses that are capable of eliciting maximal stimulation of levator ani muscle growth.

[000219] **Table 1. Animals Groups and Experimental Design**

Group #	**Castrated?**	**Drug**	**Dose**	**# of animals**
1	No	None	None	5
2	Yes	None	Vehicle only	5
3	Yes	Testosterone	0.1 mg/day	5
4	Yes	Testosterone	0.3 mg/day	5
5	Yes	Testosterone	0.5 mg/day	5
6	Yes	Testosterone	0.75 mg/day	5
7	Yes	Testosterone	1.0 mg/day	5
8	Yes	R-III	1.0 mg/day	5
9	Yes	S- III	0.1 mg/day	5

10	Yes	S- III	0.3 mg/day	5
11	Yes	S- III	0.5 mg/day	5
12	Yes	S- III	0.75 mg/day	5
13	Yes	S- III	1.0 mg/day	5
14	Yes	S- VI	0.1 mg/day	5
15	Yes	S- VI	0.3 mg/day	5
16	Yes	S- VI	0.5 mg/day	5
17	Yes	S- VI	0.75 mg/day	5
18	Yes	S- VI	1.0 mg/day	5
19	Yes	S- VII	0.1 mg/day	5
20	Yes	S- VII	0.3 mg/day	5
21	Yes	S- VII	0.5 mg/day	5
22	Yes	S- VII	0.75 mg/day	5
23	Yes	S- VII	1.0 mg/day	5
24	Yes	S- IV	0.1 mg/day	5
25	Yes	S- IV	0.3 mg/day	5
26	Yes	S- IV	0.5 mg/day	5
27	Yes	S- IV	0.75 mg/day	5
28	Yes	S- IV	1.0 mg/day	5
29	Yes	None	Vehicle only	5

EXAMPLE 3

Pharmacokinetics of Compound IV in Dogs

[000220] The pharmacokinetics of S-Compound IV, a novel selective androgen receptor modulator (SARM), were characterized in beagle dogs. A four-treatment, four-period crossover design was utilized in the study, which involved a total of six beagle dogs, three of each gender. Each animal received a 3 mg/kg IV dose, a 10 mg/kg IV dose, a 10 mg/kg PO dose in solution, and a 10 mg/kg PO dose in capsule, in a randomly assigned order. There was a one-week washout period between treatments. Plasma samples were collected for up to 72 hr after drug administration. Plasma Compound IVconcentrations were analyzed by a validated HPLC method. The clearance (CL), volume of distribution (Vss), half-life ($T_{1/2}$), and other pharmacokinetic parameters were determined by noncompartmental methods. Results showed that Compound IVwas cleared from dog plasma with a terminal $T_{1/2}$ of about 4 hr and a CL of 4.4 mL/min/kg after IV administration. Figures 4, 5, and 6 show the plasma concentration-time profiles of Compound IVafter administration of an intravenous solution, oral solution, and oral capsule, respectively. The pharmacokinetics were dose- and gender-independent. The

oral bioavailability of Compound IVvaried with the dosage form, and averaged 38% and 19% for solution and capsule, respectively. Thus, Compound IVdemonstrated moderate half-life, slow clearance and moderate bioavailability in beagle dogs, identifying it as the first of a new class of orally bioavailable tissue-selective androgen receptor modulators.

EXAMPLE 4

Compound IV Analysis by HPLC

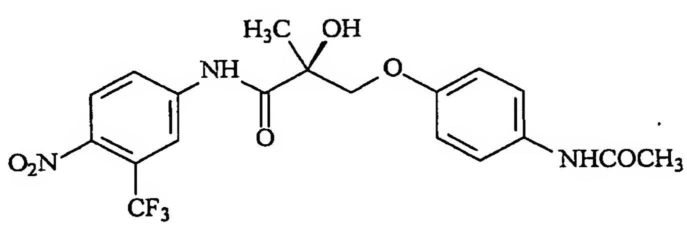
[000221] A reversed phase high pressure liquid chromatograph (HPLC) assay was developed to quantitate Compound IV concentrations in dog plasma. Dog blood samples were obtained by venipuncture and centrifuged at 1000g for 15 minutes. Samples were stored frozen at -20°C until analysis. Individual samples were rapidly thawed and an aliquot (0.5 ml) was spiked with internal standard (20 µl of a 200 µg/ml aqueous solution of CM-II-87). An aliquot of 1 ml of acetonitrile was added to the samples to precipitate plasma proteins. The samples were vortexed and then centrifuged at 1000g for 15 minutes. The supernatant was decanted into glass extraction tubes and 7.5 ml of ethyl acetate was added. The extraction mixture was left at room temperature for 20 minutes, and vortexed several times during this interval. The samples were then centrifuged at 1000g for 10 minutes, and the organic phase was removed and placed in conical-bottomed glass tubes. The organic phase was evaporated under nitrogen. The samples were reconstituted in 200 µl of mobile phase (35:65 acetonitrile:water) and transferred to an autosampler vial for HPLC injection (Waters 717 plus autosampler, Waters Corp., Milford, MA). The isocratic mobile phase of 35% (v/v) acetonitrile in water was pumped at a flow rate of 1 ml/min (Model 510, Waters Corp.). The stationary phase was a C18 reversed phase column (Novapak C18, 3.9 x 150 mm). Analytes were monitored with UV detection at 270 nm (Model 486 absorbance detector, Waters Corp.). Retention times for Compound IV and CM-II-87 were 11.1 and 16.9 minutes, respectively. Chromatography data was collected and analyzed using Millennium software. Plasma concentrations of Compound IV in each sample were determined by comparison to calibration curves. Calibration curves were constructed by adding known amounts of Compound IV to dog plasma. Final Compound IV concentrations in dog plasma samples used in the calibration curves were 0.08, 0.2, 0.4, 2, 4, 10, and 20 µg/ml. Calibration

curves were linear over this concentration range and exhibited correlation coefficients (r2) of 0.9935 or greater. Intra- and inter-day coefficients of variation for the standards ranged from 6.4% for 0.08 μg/ml to 7.9% for 20 μg/ml.

[000222] Melting points were determined on a Thomas-Hoover capillary melting point apparatus and are uncorrected. Infrared spectra were recorded on a Perkin Elmer System 2000 FT-IR. Optical rotations were determined on an Autopol® III Automatic Polarimeter (Rudolph Research Model III-589-10, Fairfield, New Jersey). Proton and carbon-13 magnetic resonance spectra were obtained on a Bruker AX 300 spectrometer (300 and 75 MHz for ^{1}H and ^{13}C, respectively). Chemical shift values were reported as parts per million (δ) relative to tetramethylsilane (TMS). Spectral data were consistent with assigned structures. Mass spectra were determined on a Bruker-HP Esquire LC System. Elemental analyses were performed by Atlantic Microlab Inc. (Norcross, GA), and found values were within 0.4 % of the theoretical values. Routine thin-layer chromatography (TLC) was performed on silica gel on aluminum plates (silica gel 60 F 254, 20 x 20 cm, Aldrich Chemical Company Inc., Milwaukee, WI). Flash chromatography was performed on silica gel (Merck, grade 60, 230-400 mesh, 60). Tetrahydrofuran (THF) was dried by distillation over sodium metal. Acetonitrile (MeCN) and methylene chloride (CH_2Cl_2) were dried by distillation from P_2O_5.

EXAMPLE 5

Metabolism of Compond IV in Rats and Dogs



IV

PURPOSE:

[000223] Compound IV is a potent and efficacious selective androgen receptor modulator (SARM). These studies evaluated the urinary and fecal metabolite profiles of

Compound IV in rats and dogs.

METHODS:

[000224] **Metabolism Studies:** Rats received a 300 mg/kg oral dose and beagle dogs received a 100 mg/kg intravenous (IV) dose of Compound IV. Urine and Feces were collected prior to dosing and at 8 and 24 hours after the dose was administered. Feces samples were homogenized in 10 mL of water per 6 g of feces. All samples were stored at -20°C until analysis. Specimens were analyzed by LC/MS/MS to determine metabolite structure.

[000225] **Radioactive Terminal Disposition Study:** Separate studies using C-14 labeled Compound IV were conducted in rats to quantify the overall disposition and mass balance of Compound IV after intravenous dosing. Catheters were implanted in the jugular vein of Sprague-Dawley rats and the animals were allowed to recover for 24 hours. Animals were then placed in plastic Nalgene® metabolism cages. An appropriate amount of [14C] Compound IV was dissolved in ethanol and diluted in PEG 300. The final concentration of ethanol was less than 5% of the dosing solution. An IV bolus dose of 100 μCi [14C] Compound IV was administered through the jugular catheter over a 5 minute period. Feces and urine samples were collected prior to dosing and at 8, 24 and 48 hours after the dose was administered. Animals were sacrificed 24 and 48 hours after dosing and the liver, spleen, heart, kidneys, intestines (small and large), levator ani muscle, pancreas, stomach wall, abdominal fat and prostate were harvested.

[000226] **Sample Preparation and LC/MS Assay:** Plasma and fecal samples were prepared using a liquid-liquid extraction method. Organ samples were weighed and minced with a scalpel. Aliquots of each organ samples were placed in 1 mL of ScintiGest® tissue solubilizer (Fisher Scientific Company, Fair Lawn, NJ), and then homogenized using a Pro 200 homogenizer (Pro Scientific, Monroe, CT). The samples were incubated at 60°C until tissue dissolved. The total radioactivity of the tissues, urine, and fecal samples were determined using a Beckman LS6000 IC liquid scintillation counter (Beckman-Coulter, Fullerton, CA). Radioactive urine and feces samples were

also separated using a reversed phase column to identify the fractions of parent drug and metabolites. Eluent fractions from the HPLC were collected in 2 minute intervals and counted as as described above. Nonradioactive urine and feces samples were filtered and analyzed by LC/MSn. The LC/MS system consisted of a Surveyor MS pump, Surveyor autosampler, and LCQ Deca MS (Thermo-Finnigan, San Jose, CA). Blank feces and urine samples were used to subtract the background spectra from that of the treated samples to identify drug related peaks. Metabolite ID software was used to identify metabolite peaks by comparing the MS and MS2 of the metabolite spectra to that of authentic Compound IV.

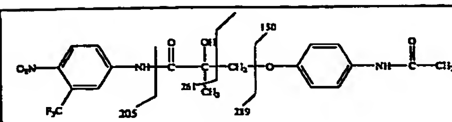
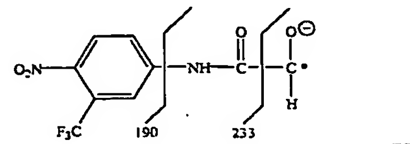
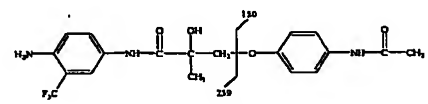
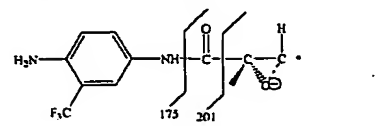
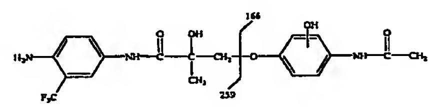
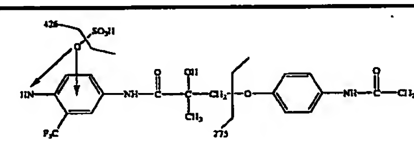
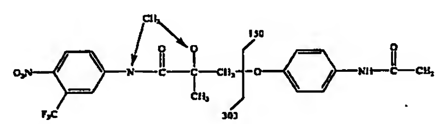
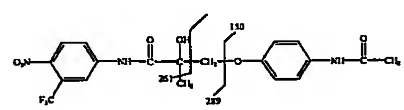
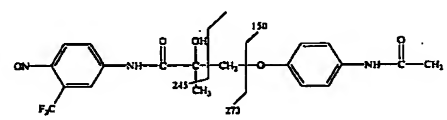
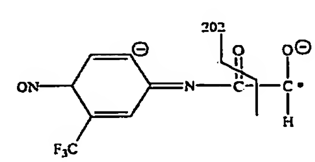
RESULTS:

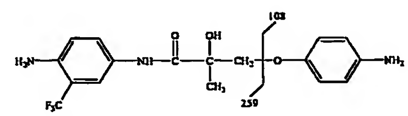
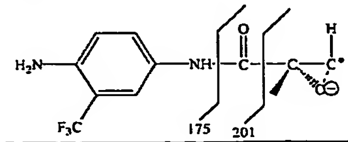
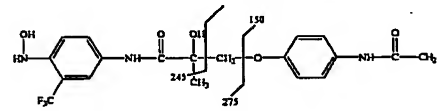
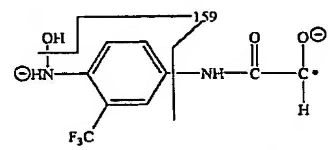
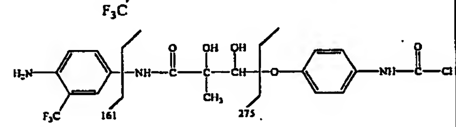
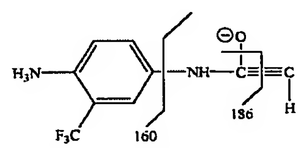
[000227] **MS2 Spectra of Compound IV and its Amine Metabolite.** Fragmentation of Compound IV (*m/z* 440) produced three major daughter ions (*m/z* 150, 261, and 289) (Figure 10A). The site of metabolic conversion was identified by comparing the fragmentation pattern of Compound IV to its amine metabolite (*m/z* 410) (Figure 10B). In addition, MS3 spectra were obtained for the major daughter ions of each metabolite and Compound IV to further verify the structure (Not shown).

[000228] **Proposed Fragmentation Pattern and Metabolites of COMPOUND IV in Rats and Dogs.** Metabolite structure was determined using LC/MS and LC/MS2 fragmentation of metabolite peaks. Fragmentation patterns of the metabolites were compared to the parent compound to determine the sites of metabolic modification. The results are presented in Table 2. Bottom structures in each row show structural information gathered by LC/MS2 fragmentation.

Table 2

Molecular Ion [M-H]-	Produce Ion (m/z values)	Assigned Structures and Proposed Fragmentation Pattern

440 (Compound IV)	150, 205, 261, 289	
Daughter Ion 261	190, 218, 233	
410	150, 259, 308, 380	
Daughter Ion 259	175, 201, 209	
426	166, 220, 259, 324, 336, 365, 396, 408	 [M-H2O]- 408
506 Daughter Ion 426	225, 275, 366, 406, 426 275	
454	150, 303	
440 (Compound IV)	150, 205, 261, 289	
424 (Compound IV – O)	150, 245, 273	
Daughter Ion 245	183,202	

368	108, 175, 201, 231, 259	
Daughter Ion 259	175, 201, 209	
426	150, 245, 275, 405	
Daughter Ion 245	159	
	161, 216, 275	
Daughter Ion 216	160, 186	

Radioactive Terminal Disposition

[000229] **Radiographs of 24-hour Rat Urine and Feces samples.**

A. Urine (Figure 11A): Two major peaks can be seen at 5 and 47 minutes. The peak at 5 minutes (hydrolysis product) corresponds to 25% of the injected dose, while the smaller peak at 47 minutes (amine metabolite) corresponds to 11% of the injected dose.

B. Feces (Figure 11B): Two major peaks can be seen at 43 and 51 minutes, with three minor peaks at 7, 15 and 27 minutes. The peak at 51 minutes (parent compound) corresponds to 18.5% of the injected dose. The three minor peaks (phase II metabolites) correspond to 0.8% of the injected dose.

[000230] **Proposed Metabolic Profile in Dogs and Rats.** The major metabolite of Compound IV is the hydrolysis product found in rat urine. The N-deactylated metabolite (*m/z* 368) was unique to dogs. All phase II metabolites were found in the feces. The metabolic profile of Compound IV is summarized in Figure 12.

CONCLUSIONS:

[000231] Compound IV was the first of several novel nonsteroidal androgens that were identified during *in vitro* screening for selective androgen receptor modulators (SARMs). Compound IV demonstrated linear pharmacokinetics and dose dependant oral bioavailability. The data in these studies show that Compound IV was extensively metabolized, with less than 1% of unchanged parent drug found in the urine of rat and dogs. Urine and fecal metabolite profiles showed that Compound IV was metabolized by both phase I and phase II metabolic enzymes.

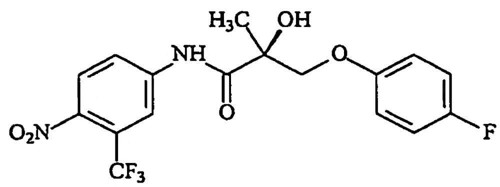
[000232] Metabolic and final disposition studies of Compound IV showed:

1. Both urinary and fecal metabolites, with the major metabolite being the hydrolysis product formed from the cleavage of the amide bond.
2. A large portion of the injected dose was found as the parent compound in feces. This my be due to biliary excretion of the parent compound or its glucuronidated metabolites.
3. The N-deactylated metabolite found in dog urine was shown to be an androgen receptor antagonist in *in vitro* transcriptional activation studies. However, no significant levels of this metabolite were found in the radioactive disposition studies in rats. This is because rat possess N-Acetyltranferase, while dogs do not.

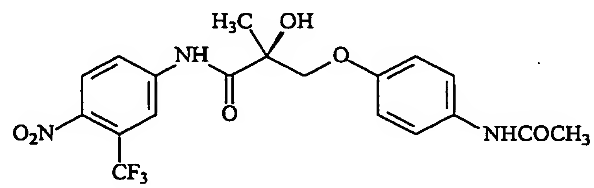
[000233] In summary, the metabolism of Compound IV differed greatly from bicalutamide. A nitro-reduced product of Compound IV was identified as the major metabolite in rats and dogs. Rat and dogs showed similar metabolic profiles, although an N-deactylated metabolite of Compound IV that was found in dogs could not be identified in rats. This N-deactylated product was shown to be an androgen antagonist in *in vitro* studies.

EXAMPLE 6

Phase I metabolism study of Selective Androgen Receptor Modulators (SARMs) – Compounds III and IV with Human Liver Microsomes



III



IV

PURPOSE:

[000234] Compounds III are IV are potent and efficacious selective androgen receptor modulators (SARMs). The purpose of this *in vitro* study was to identify the main phase I metabolites and the cytochrome P450s involved in the phase I metabolism of compounds III and IV using pooled human liver microsome (HLM), and recombinant CYPs.

METHODS:

[000235] ***In vitro* metabolism of Compound III and Compound IV by human recombinant CYP Supersomes®:** Human recombinant CYP Supersomes® were purchased from BD Gentest (Woburn, MA). All the specimens were thawed at 37°C, and the incubations were conducted in duplicate using 40 pmole of enzyme with 2μM Compound IV in reaction buffer for 2 hours at 37°C. Control samples were prepared in the same way except that no enzyme preparation was added. The reaction was stopped by the addition of ice-cold acetonitrile (1:1, v:v) containing an internal standard for HPLC analysis. The concentration of Compound III and Compound IV in each incubate was measured by HPLC. Both Compounds III and IV were detected by their UV absorbance at 230 nm.

[000236] **Identification of *in vitro* metabolites of Compounds III and IV by HLM:** Human liver microsomes were incubated with 2μM Compound III or Compound IV in 100 mM phosphate buffer (pH 7.5) and 1 mM NADPH for 2 hours at 37°C. The

reaction was stopped by the addition of ice-cold acetonitrile (1:1, v:v). After precipitation of proteins, the supernatant was analyzed with LC-MS to identify the main metablites in the incubates.

[000237] **Measurement of the kinetic parameters for M1 formation by HLM and human recombinant CYPs:** HLM (0.2 mg/ml) or recombinant CYPs (10 pmole each reaction) were incubated with NADPH (1mM) and Compound IV (0.2 μM to 150 μM). Incubates were maintained at 37°C for 10 minutes, and the reaction was stopped by the addition of ice-cold acetonitrile (1:1, v:v) containing internal standards for HPLC analysis. The concentration of M1 in each incubate was measured by HPLC. The initial reaction velocity was calculated based on the appearance of M1, and was plotted versus initial substrate concentrations. The standard substrates, phenacetin, diclofenac, mephenytoin, bufuralol and testosterone were also included to test the activities of CYP1A2, CYP2C9, CYP2C19, CYP2D6 and CYP3A4 respectively. The kinetic parameters Km and Vmax were determined by nonlinear regression analysis using WinNonlin (version 4.0, Pharsight Corporation, Mountain View, CA) and the sigmoidal Emax model.

RESULTS:

[000238] ***In vitro* metabolism of Compound IV by human recombinant CYP Supersomes® (n=2).** Compound IV (2 μM) was incubated with human recombinant CYP Supersomes® (40 pmole) at 37°C for 2 hours. The disappearance of Compound IV was measured. As depicted in Figure 13, after incubation, more than 95% of Compound IV was metabolized by human CYP3A4.

[000239] ***In vitro* metabolism of Compound III by human recombinant CYP Supersomes® (n=2).** Compound III (2 μM) was incubated with human recombinant CYP Supersomes® (40 pmole) at 37°C for 2 hours. The disappearance of Compound III was measured. As depicted in Figure 14, after incubation, 20% of Compound III was metabolized by human CYP3A4.

[000240] ***In vitro* metabolism of Compound IV in HLM.** As shown in Figure 15, the main phase I metabolism of Compounds includes deacetylation of the amino group

(M1), hydrolysis of the amide bond and oxidation.

[000241] ***In vitro* metabolism of Compound III in HLM.** As shown in Figure 16, the main *in vitro* metabolism pathway of Compound III in HLM is oxidation.

[000242] ***In vitro* metabolism of Compound IV to M1 by CYPs.** The appearance of M1 was measured in triplicate. The kinetic parameters for CYP3A4 are: Km (1.65 μM) and Vmax (19.7 nmole/(pmole CYP*min)) were determined after incubation of Compound IV (0.2 μM to 100 μM) with CYPs. M1 was not detected when lower concentrations of Compound IV were incubated with CYP2C19, CYP2D6 and CYP1A2. At the concentrations tested, no M1 was formed when Compound IV was incubated with CYP2C9. The results are shown in Figure 17.

[000243] ***In vitro* metabolism of Compound IV to M1 by HLM (0.2 mg/ml).** The appearance of M1 was measured in triplicate. The kinetic parameters Km (58.4 μM) and Vmax (348.6 pmole/(mg protein*min)) were determined after incubation of Compound IV (2 μM to 150 μM) with HLM. The results are shown in Figure 18.

CONCLUSIONS:

[000244] Cytochrome P450-mediated oxidation is the major pathway for metabolism of Compound III in HLM.

[000245] CYP3A4-mediated deacetylation is the major pathway for metabolism of Compound IV in HLM. Oxidation and hydrolysis also occur, but to lesser extents.

[000246] The apparent Km of 1.65 μM for Compound IV with recombinant CYP3A4 is much lower than the apparent Km for M1 formation in HLM (58.4 μM, Figure 18). This is likely due to the presence of CYPs 2C19, 2D6 and 1A2 which contribute to M1 formation at higher concentrations of Compound IV.

[000247] CYP3A4 appears to be the main phase I enzyme that will contribute to Compound IV metabolism at clinically relevant concentrations.

[000248] In summary, Compounds III and IV are nonsteroidal SARMs that demonstrate tissue-selective androgenic and anabolic effects (JPET 304(3):1334-1340, 2003). Preliminary *in vitro* phase I metabolism studies with human liver microsomes showed that both Compound III (2 μM) and Compound IV (2 μM) are mainly metabolized by CYP3A4.

[000249] It will be appreciated by a person skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather, the scope of the invention is defined by the claims that follow: